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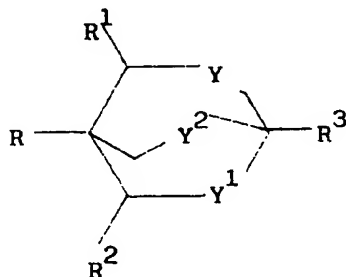
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(54) Pesticidal compounds.

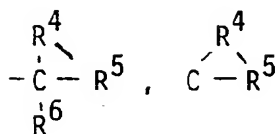
(57) The present invention provides novel compounds of the formula (I):



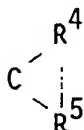
(I)

wherein R is a phenyl group, substituted by 1 to 5 fluorine atoms and optionally substituted at the para position by methyl or chloro or R is a group

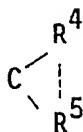
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being a three or four membered ring, where R^4 is oxygen or a group CR^7R^8 wherein groups R^7 , R^8 are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, and when



is a three-membered ring R^5 is a group $\text{CR}^{7a}\text{R}^{8a}$ wherein R^{7a} , R^{8a} are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, or when



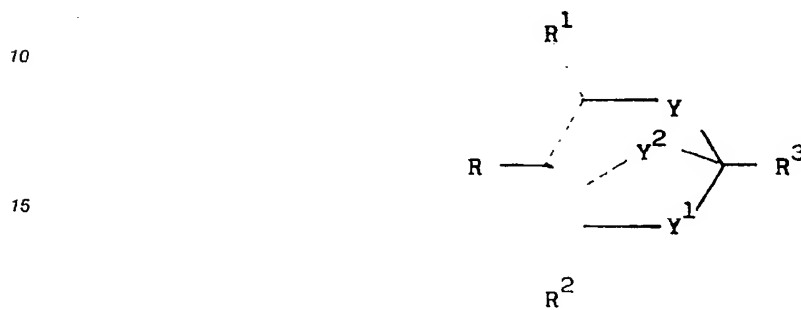
is a four membered ring R^5 is a group $\text{CR}^{7a}\text{R}^{8a}\text{CR}^9\text{R}^{10}$ wherein R^{7a} , R^{8a} are as hereinbefore defined and R^9 and R^{10} are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms; R^6 is hydrogen, fluoro, chloro or methyl; R^1 and R^2 may be the same or different, and each is hydrogen, halo, or a C_{1-3} aliphatic group optionally substituted by halo, cyano, C_{2-5} carbalkoxy, C_{1-4} alkoxy, or a group $\text{S}(\text{O})_m \text{R}^{11}$ wherein m is 0, 1 or 2 and R^{11} is C_{1-4} alkyl; cyano, gem dimethyl, or C_{2-5} carbalkoxy; R^3 contains between 3 and 18 carbon atoms and is a group R^{12} wherein R^{12} is a C_{1-13} non-aromatic hydrocarbonyl group, optionally substituted by a C_{2-4} carbalkoxy or cyano group and/or by one or two hydroxy groups and/or by one to five halo atoms which are the same or different and/or by one to three groups R^{13} which are the same or different and each contains one to four hetero atoms, which are the same or different and are chosen from oxygen, sulphur, nitrogen and silicon, 1 to 10 carbon atoms and optionally 1 to 6 fluoro or chloro atoms or R^3 is a 6-membered aromatic ring substituted by cyano and/or by one to five halo atoms and/or by one to three C_{1-4} haloalkyl groups and/or by a group $-\text{C}\equiv\text{CH}$, $\text{C}\equiv\text{C}-\text{halo}$ or $-\text{C}\equiv\text{C}-\text{R}^{12}$ wherein R^{12} is as hereinbefore defined or $-\text{C}\equiv\text{C}-\text{R}^{14}$ wherein R^{14} is a group $\text{S}(\text{O})_t \text{R}^{15}$ wherein R^{15} is methyl, ethyl or trifluoromethyl or R^{14} is $\text{SiR}^{16}\text{R}^{17}\text{R}^{18}$ wherein R^{16} and R^{17} are the same or different and are each C_{1-4} aliphatic groups and R^{18} is a C_{1-4} aliphatic group or phenyl provided that R^{16} , R^{17} and R^{18} do not contain more than 10 carbon atoms in total; and Y , Y^1 and Y^2 are the same or different and are each selected from oxygen and $\text{S}(\text{O})_t$ where t is 0, 1 or 2, processes for their preparation, formulations containing them and their use in controlling pest infestation.

PESTICIDAL COMPOUNDS

The present invention relates to novel chemical compounds having pesticidal activity, to methods for their preparation, to compositions containing them and to their use in the control of pests. More particularly the invention relates to a class of heterobicycloalkanes.

The use of certain 2,6,7-trioxabicyclo[2.2.2]octanes is disclosed in European Patent Applications Nos. 152229, 211598, 216625 and 216624. It has now been discovered that certain of these compounds have particularly interesting pesticidal activity.

Accordingly, the present invention provides a compound of the formula (I):



wherein R is a phenyl group, substituted by 1 to 5 fluorine atoms and optionally substituted at the para position by methyl or chloro or R is a group



being a three or four membered ring, where R^4 is oxygen or a group CR^7R^8 wherein groups R^7 , R^8 are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, and when



is a three-membered ring R^5 is a group $CR^{7a}R^{8a}$ wherein R^{7a} , R^{8a} are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, or when



is a four membered ring R^5 is a group $CR^{7a}R^{8a}CR^9R^{10}$ wherein R^{7a} , R^{8a} are as hereinbefore defined and R^9 and R^{10} are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms; R^6 is hydrogen, fluoro, chloro or methyl; R^1 and R^2 may be the same or different, and each is hydrogen, halo, or a C_{1-3} aliphatic group optionally

substituted by halo, cyano, C₂₋₅ carbalkoxy, C₁₋₄ alkoxy, or a group S(O)_m R¹¹ wherein m is 0, 1 or 2 and R¹¹ is C₁₋₄ alkyl; cyano, gem dimethyl, or C₂₋₅ carbalkoxy; R³ contains between 3 and 18 carbon atoms and is a group R¹² wherein R¹² is a C₁₋₁₃ non-aromatic hydrocarbyl group, optionally substituted by a C₂₋₄ carbalkoxy or cyano group and/or by one or two hydroxy groups and/or by one to five halo atoms which are the same or different and/or by one to three groups R¹³ which are the same or different and each contains one to four hetero atoms, which are the same or different and are chosen from oxygen, sulphur, nitrogen and silicon, 1 to 10 carbon atoms and optionally 1 to 6 fluoro or chloro atoms or R³ is a 6-membered aromatic ring substituted by cyano and/or by one to five halo atoms and/or by one to three C₁₋₄ haloalkyl groups and/or by a group -C≡CH, -C≡C-halo, -C≡C-R¹² wherein R¹² is as hereinbefore defined or -C≡C-R¹⁴ wherein R¹⁴ is a group S(O)_qR¹⁵ wherein q is 0, 1 or 2 and R¹⁵ is methyl, ethyl or trifluoromethyl or R¹⁴ is SiR¹⁶R¹⁷R¹⁸ wherein R¹⁶ and R¹⁷ are the same or different and are each C₁₋₄ aliphatic groups and R¹⁸ is a C₁₋₄ aliphatic group or phenyl provided that R¹⁶, R¹⁷ and R¹⁸ do not contain more than 10 carbon atoms in total; and Y, Y¹ and Y² are the same or different and are each selected from oxygen and S(O)_t where t is 0, 1 or 2.

By the term "halo" is meant fluoro, chloro, bromo or iodo.

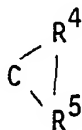
By the term "non-aromatic hydrocarbyl" group is meant an alkyl, alkenyl or alkynyl group (including a cyclic alkyl or alkenyl group optionally substituted by alkyl, alkenyl or alkynyl; and alkyl or alkenyl substituted by cyclic alkyl and alkenyl).

By the term "6-membered aromatic ring" is meant phenyl and heteroaromatic rings such as pyridyl.

In one embodiment of the present invention R is a phenyl group substituted by 1 to 5 fluorine atoms and optionally substituted at the para position by methyl or chloro.

Suitably R is phenyl substituted by one or two fluorine atoms.

In a second embodiment of the present invention R is a group



as hereinbefore defined. Suitably R is a cyclopropyl or cyclobutyl group, each optionally substituted by methyl.

Suitably R¹ is hydrogen, cyano, methyl or ethyl each optionally substituted by cyano, methoxy, methylthio, chloro, bromo or fluoro. Most suitably R¹ is hydrogen, methyl, cyano or trifluoromethyl.

Preferably R¹ is hydrogen.

Suitably R² is hydrogen, cyano, methyl or trifluoromethyl. Preferably R² is hydrogen.

R³ suitably contains between 3 and 12 carbon atoms. Preferably there is only one silyl group present. The sulphur atoms present may be in an oxidised form if desired. Preferably there is a maximum of two sulphur atoms present in R³. Suitably there is a maximum of four and preferably a maximum of three oxygen atoms in R³. Preferably there is only one nitrogen atom present in R³. R³ is suitably a C₃₋₉ alkyl, alkenyl or alkynyl group, each of which may be optionally substituted by halo or a group R¹³, or R³ is a substituted phenyl or cyclohexyl group. The group R¹³ is linked to the hydrocarbyl group via a hetero atom of R¹³. Suitable substituents R¹³ for the group R¹² include alkoxy, alkenyloxy, alkynyloxy, alkoxyalkoxy, acyloxy, alkynyloximino, trialkylsilyl, haloalkoxy, haloalkenyloxy, haloalkynyloxy, alkyloximino, alkoxy carbonyloxy and mono or di-substituted alkylamino groups or a group -(O)_nS(O)_r(O)_wR¹⁹ wherein R¹⁹ is a C₁₋₄ aliphatic group optionally substituted by halo, n is 0 or 1, r is 0, 1 or 2 and w is 0 or 1, the sum of n, r and w being between 0 and 3. When a silyl group is present this is normally adjacent to an ethynyl group. Preferred substituents R¹³ include alkoxy, alkoxyalkoxy, alkenyloxy, alkynyloxy, haloalkoxy, haloalkenyloxy and haloalkynyloxy. Suitably R¹² is substituted by up to two substituents R¹³ and preferably R¹² is unsubstituted or contains one substituent R¹³.

In one suitable embodiment, R³ is a phenyl group substituted at the 3-, 4- or 5-positions by one to three substituents each selected from halo, C₁₋₄ haloalkyl, cyano, or a group (C≡C)_pR²⁰ wherein p is 1 or 2 and R²⁰ is hydrogen, bromo, chloro, iodo; or R²⁰ is an aliphatic group containing up to five carbon atoms optionally substituted by C₁₋₄ alkoxy, C₁₋₆ alkoxyalkoxy, C₁₋₈ acyloxy, halo or hydroxy; or R²⁰ is SiR¹⁶R¹⁷R¹⁸ wherein R¹⁶, R¹⁷ and R¹⁸ are as hereinbefore defined. When R³ is a substituted phenyl group it is additionally optionally substituted at the 2- and/or 6-positions by fluoro or chloro.

In one preferred embodiment R³ is phenyl substituted at the 3-, 4- or 5- positions by one to three substituents each selected from halo, cyano, C₁₋₄ haloalkyl or a group C≡C-R²¹ where R²¹ is hydrogen, or

methyl or ethyl each optionally substituted by hydroxy, methoxy, ethoxy, acetoxy; or R^{21} is ethynyl, or a silyl group substituted by three C_{1-4} alkyl groups, R^3 is additionally optionally substituted at the 2- and/or 6- positions by fluoro or chloro. Preferably R^3 is phenyl para substituted by a group $-C\equiv C-R^{22}$ wherein R^{22} is hydrogen.

5 In a second preferred embodiment R^3 is a group $-B(C\equiv C)Z$, wherein B is a C_{3-5} aliphatic chain optionally containing a double bond and/or an oxygen atom and/or a group $S(O)_q$ wherein q is 0, 1 or 2, and optionally substituted by halo, C_{1-4} alkyl, C_{1-4} haloalkyl, C_{2-4} carbalkoxy or cyano and Z is hydrogen, C_{1-5} alkyl, C_{1-3} alkoxymethyl or a group $SiR^{16}R^{17}R^{18}$ wherein R^{16} , R^{17} and R^{18} are as hereinbefore defined.

10 In a third preferred embodiment R^3 is a group $-DZ^1$, wherein D is a group $-CH_2O-$ or $CH_2S(O)_q$ wherein q is 0, 1 or 2 or a C_{2-3} aliphatic group each of which may be optionally substituted by one to three halo atoms and Z^1 is silyl substituted by three C_{1-4} alkyl groups or Z^1 is a group



20 wherein R^{23} , R^{24} and R^{25} are the same or different and are each independently selected from halo, cyano, C_{2-5} carbalkoxy, or a C_{1-4} aliphatic group optionally substituted by halo, cyano, C_{2-5} carbalkoxy, C_{1-4} alkoxy or a group $S(O)_qR^{26}$ wherein q is 0, 1 or 2 and R^{26} is C_{1-4} alkyl, or R^{23} , R^{24} and R^{25} are selected from C_{1-4} alkoxy or a group $S(O)_zR^{27}$ wherein z is 0, 1 or 2 and R^{27} is C_{1-4} alkyl optionally substituted by fluoro or R^{23} and R^{24} are linked to form a C_{3-6} cycloalkyl ring, or one or R^{23} , R^{24} and R^{25} may be hydrogen.

25 Suitably R^4 is oxygen, CH_2 , CF_2 , $CHMe$ or $C(Me)_2$. Suitably R^5 is CH_2 , CF_2 , $C(Me)_2$ or CH_2CH_2 . Suitably R^6 is hydrogen or methyl.

By the term "aliphatic group" is meant an alkyl, alkenyl or alkynyl group.

Most suitably D is a group $-C\equiv C-$, $-CH=CH-$ or $-CH_2CH_2-$.

30 Preferably Z^1 is tertiary butyl, trichloromethyl or 2-methoxyprop-2-yl.

In a fourth preferred embodiment R^3 is a group



wherein Z is as hereinbefore defined:

A preferred group of compounds of the formula (I) is that in which R^3 contains a $-(C\equiv C)-$ fragment or terminates in a group Z^1 as hereinbefore defined.

- 45 4-Cyclobutyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
4-Cyclobutyl-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
4-Cyclobutyl-1-[4-(prop-1-ynyl)phenyl]-2,6,7-trioxabicyclo[2.2.2]octane
4-Cyclobutyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
4-Cyclobutyl-1-(hex-5-ynyl)-2,6,7-trioxabicyclo[2.2.2]octane
50 3-Cyano-4-cyclobutyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
3-Cyano-4-cyclobutyl-1-(hex-5-ynyl)-2,6,7-trioxabicyclo[2.2.2]octane
4-Cyclopropyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
4-Cyclopropyl-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
4-Cyclopropyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
55 4-Cyclopropyl-1-[4-(prop-1-ynyl)phenyl]-2,6,7-trioxabicyclo[2.2.2]octane
1-(4-iodophenyl)-4-(trans-2-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane
4-(trans-2-Methylcyclopropyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane

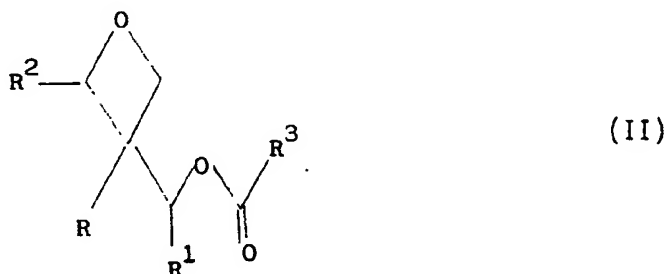
1-(4-Ethynylphenyl)-4-(trans-2-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane
 4-(trans-2-Methylcyclopropyl)-1-[4-(prop-1-ynyl)phenyl]-2,6,7-trioxabicyclo[2.2.2] octane
 1-(4-Iodophenyl)-4-(1-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane
 4-(1-Methylcyclopropyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 5 1-(4-Ethynylphenyl)-4-(1-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane
 4-(1-Methylcyclopropyl)-1-[4-(prop-1-ynyl)phenyl]-2,6,7-trioxabicyclo[2.2.2]octane
 4-(3-Fluorophenyl)-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 4-(4-Fluorophenyl)-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 4-(3-Fluorophenyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 10 4-(4-Fluorophenyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 1-(4-Ethynylphenyl)-4-(3-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 1-(4-Ethynylphenyl)-4-(2-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 1-(4-Ethynylphenyl)-4-(4-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 4-(3,4-Difluorophenyl)-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane
 15 4-(4-Fluorophenyl)-1-[4-(prop-1-ynyl)phenyl]-2,6,7-trioxabicyclo[2.2.2]octane

The compounds of the formula (I) may exist in a number of isomeric forms. The present invention provides individual isomers of compounds of the formula (I) and mixtures thereof. The present invention also encompasses compounds of the formula (I) containing radioisotopes, particularly those in which one carbon atoms is C¹⁴ or one to three hydrogen atoms are replaced by tritium.

In a further aspect, the present invention provides a process for the preparation of a compound of the formula (I). The process for the preparation of a compound of the formula (I) may be any method known in the art for preparing analogous compounds, for example :

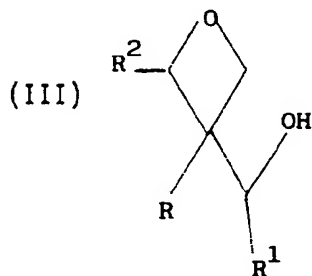
(i) when Y, Y¹ and Y² are oxygen:

by the cyclisation of a compound of the formula (II) :

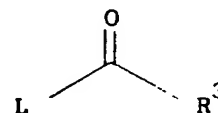


wherein R to R³ are as hereinbefore defined, in the presence of an acid catalyst. Boron trifluoride etherate is a particularly preferred acid catalyst for this cyclisation which will normally be carried out in an inert solvent, such as a halogenated hydrocarbon, conveniently dichloromethane, at or below ambient temperature, for example between -100 and 50°C and conveniently between -70 and -25°C.

The compounds of the formula (II) may be prepared by the reaction of compounds of the formulae (III) and (IV):



(IV)



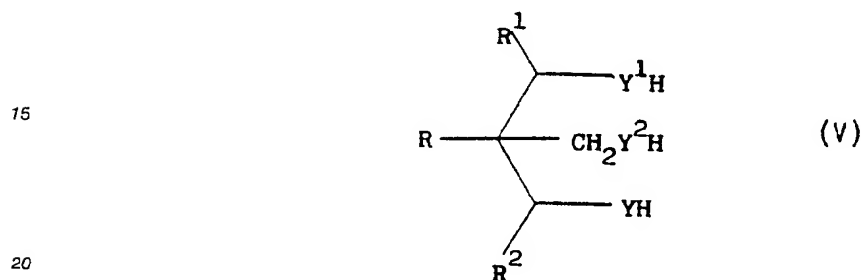
where R to R³ are as hereinbefore defined and L is a leaving group such as halo or hydroxy. This reaction conveniently takes place under conditions well known to those skilled in the art, for example when L is halo in an inert solvent in the presence of base at a non-extreme temperature and when L is hydroxy in an inert

solvent in the presence of a condensing agent at a non extreme temperature. When L is halo, halogenated hydrocarbons, such as dichloromethane, are particularly suitable inert solvents and pyridine is a preferred base; when L is hydroxy, dimethylformamide is a suitable solvent, dicyclohexylcarbodiimide is a preferred condensing agent; and the reaction will conveniently be carried out at between -50 and 100°C, preferably between 0 and 25°C.

The compounds of the formula III may be prepared as described in copending European Patent Applications Nos. 211598 and 216624. The compounds of the formula (IV) may be prepared by methods well known to those skilled in the art.

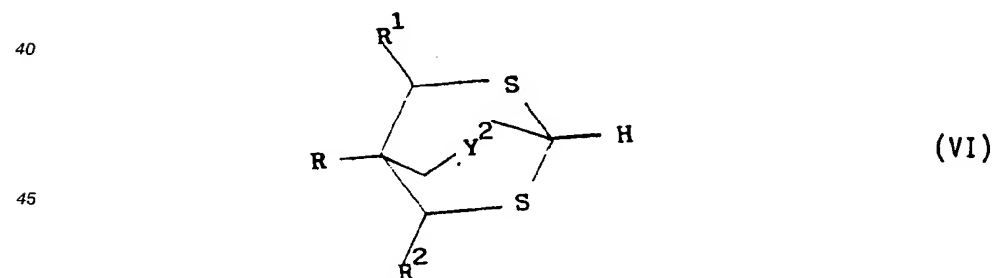
(ii) when Y, Y¹ and Y² are each oxygen or sulphur

by the reaction of a compound of the formula (V) with a compound of the formula (AlkO)₃CR³



wherein R to R³, Y, Y¹ and Y² are as hereinbefore defined and Alk is a C₁₋₄ alkyl group. The condensation takes place in the presence of an acid catalyst for example a mineral acid such as concentrated hydrochloric acid or boron trifluoride etherate or sulphonic acid resins and/or p-toluenesulphonic acid. The reaction is conveniently carried out without a solvent, but an inert solvent, conveniently toluene or a chlorinated hydrocarbon such as dichloromethane may be added. The reaction can also be carried out in methanol containing hydrogen chloride. The reaction is conveniently carried out at a non-extreme temperature, for example between -70°C and 150°C and normally between -10°C and 150°C. The compounds of the formula (V) may be prepared as described in European Patent Application No 216624. Compounds of the formula (V) wherein Y=Y¹=Y²=S and R¹=R²=H may also be prepared by the method described by G. R. Franzen and G. Binsch, *J.Amer.Chem.Soc.*, 1973, 95, 175 and D.J.Martin and C.R.Creco, *J.Org.Chem.*, 1968, 33, 1275. The compounds of the formula (AlkO)₃CR³ may be prepared by a general procedure for the synthesis of orthoesters and is described by S.M.McElvain and R.E.Starn, *J.Amer.Chem.Soc.*, 1955, 77, 4571:

(iii) when Y² = sulphur or oxygen and Y and Y¹ are sulphur by reaction of a compound of the formula (VI)



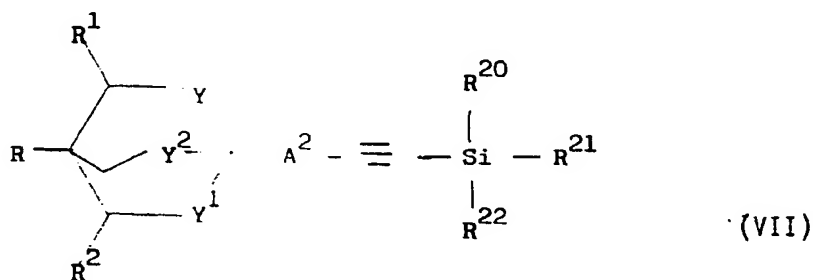
with a compound L'R³ wherein R to R³, are as hereinbefore defined, Y² is sulphur or oxygen and L' is a leaving group eg.halo. The reaction is suitably carried out in the presence of a strong base, such as an alkyllithium, in an inert solvent, such as an ether and conveniently tetrahydrofuran at a non-extreme temperature, such as between -70° and 30°C. The compound of the formula (VI) can be prepared by the reaction of the appropriate compound of the formula (V) with HC(OAlk)₃ under the conditions described for reaction (ii) above.

(iv) By the interconversion of compounds of the formula (I), for example

a) when it is desired to prepare a compound of the formula (I) wherein R³ contains a non-terminal

C≡C fragment by the reaction of the compound wherein R³ is a group A¹ C≡CH with a compound A² hal wherein hal is halogen and A¹C≡CA² is the desired group R³, A² being other than hydrogen. This reaction is particularly suitable for the preparation of those compounds wherein A² is a C₁₋₄ alkyl group or C₂₋₄ carbalkoxy group; or A² is a substituted silyl group. The reaction is normally carried out in the presence of a strong base, such as an alkyl lithium conveniently butyllithium in an inert solvent, such as an ether, for example tetrahydrofuran, at a non-extreme temperature, for example between -50° and 50°C and conveniently between -10° and 30°C. The starting material, e.g. the unsubstituted alkynylalkyl or alkynylaryl bicycloalkane may be prepared as described above.

(b) when R³ terminates in a C≡CH group by desilylation of a compound of the formula (VII)



wherein R, R¹, R², R¹⁶, R¹⁷, R¹⁸, Y, Y¹ and Y² are as defined and A³ C≡CH is the desired group R³. This reaction may be carried out by methods well known to those skilled in the art, for example by reaction with tetrabutylammonium fluoride in an ether, such as tetrahydrofuran, at a non-extreme temperature, for example between 0° and 70°C and conveniently at 25°C.

(c) by the reaction of the corresponding compound which contains iodo or bromo in place of -C≡C-R¹² or C≡C-R¹⁴ with a compound HC≡CR¹² or HC≡CR¹⁴ wherein R¹² and R¹⁴ are as hereinbefore defined. This reaction is carried out in the presence of a suitable palladium catalyst well known to those skilled in the art for this type of reaction, for example bis-triphenylphosphine palladium dichloride, and a catalytic amount of a cuprous halide, such as cuprous iodide when the starting material contains an iodo group and palladium acetate and triphenyl phosphine when the starting material contains a bromo group. The reaction will normally be carried out in the presence of basic solvent such as diethylamine or triethylamine at a non-extreme temperature, for example between -50° and 100° C and conveniently at room temperature.

It will be apparent to those skilled in the art that some compounds of the formula (I) may be susceptible to degradation under some of the reaction conditions described above, these compounds will be prepared by other methods.

Novel chemical intermediates also form an important aspect of the present invention. Preferred intermediates include those of the formula (II), (V), (VII), (XIV) and (XV).

The compounds of formula (I) may be used to control pests such as arthropods e.g. insect and acarine pests, and helminths, i.e. nematodes. Thus, the present invention provides a method for the control of arthropods and/or helminths which comprises administering to the arthropod and/or helminth or to their environment an arthropodically effective amount of a compound of the formula (I).

The present invention also provides a method for the control and/or eradication of arthropod and/or helminth infestations of animals (including humans) and/or of plants, (including trees) and/or stored products which comprises administering to the animal or locus an effective amount of a compound of the formula (I). The present invention further provides for the compounds of the formula (I) for use in human and veterinary medicine, in public health control and in agriculture for the control of arthropod and/or helminth pests.

The compounds of formula (I) are of particular value in the protection of field, forage, plantation, glasshouse, orchard and vineyard crops, of ornamentals and of plantation and forest trees, for example, cereals (such as maize, wheat, rice, sorghum), cotton, tobacco, vegetables and salads (such as beans, cole crops, cucurbits, lettuce, onions, tomatoes and peppers), field crops (such as potato, sugar beet, ground nuts, soyabean, oil seed rape), sugar cane, grassland and forage (such as maize, sorghum, lucerne), plantations (such as of tea, coffee, cocoa, banana, oil palm, coconut, rubber, spices), orchards and groves (such as of stone and pip fruit, citrus, kiwifruit, avocado, mango, olives and walnuts), vineyards, ornamental plants, flowers and shrubs under glass and in gardens and parks, forest trees (both deciduous and evergreen) in forests, plantations and nurseries.

They are also valuable in the protection of timber (standing, felled, converted, stored or structural) from

attack by sawflies (e.g. Urocetus) or beetles (e.g. scolytids, platypodids, lyctids, bostrychids, cerambycids, anobiids).

They have applications in the protection of stored products such as grains, fruits, nuts, spices and tobacco, whether whole, milled or compounded into products, from moth, beetle and mite attack. Also
 5 protected are stored animal products such as skins, hair, wool and feathers in natural or converted form (e.g. as carpets or textiles) from moth and beetle attack; also stored meat and fish from beetle, mite and fly attack.

The compounds of general formula I are of particular value in the control of arthropods or helminths which are injurious to, or spread or act as vectors of diseases in man and domestic animals, for example
 10 those hereinbefore mentioned, and more especially in the control of ticks, mites, lice, fleas, midges and biting, nuisance and myiasis flies.

The compounds of Formula (I) may be used for such purposes by application of the compounds themselves or in diluted form in known fashion as a dip, spray, fog, lacquer, foam, dust, powder, aqueous suspension, paste, gel, cream, shampoo, grease, combustible solid, vapourising mat, combustible soil, bait,
 15 dietary supplement, wettable powder, granule, aerosol, emulsifiable concentrate, oil suspensions, oil solutions, pressure-pack, impregnated article, pour on formulation or other standard formulations well known to those skilled in the art. Dip concentrates are not applied per se, but diluted with water and the animals immersed in a dipping bath containing the dip wash. Sprays may be applied by hand or by means of a spray race or arch. The animal, soil, plant or surface being treated may be saturated with the spray by
 20 means of high volume application or superficially coated with the spray by means of light or ultra low volume application. Aqueous suspensions may be applied in the same manner as sprays or dips. Dusts may be distributed by means of a powder applicator or, in the case of animals, incorporated in perforated bags attached to trees or rubbing bars. Pastes, shampoos and greases may be applied manually or distributed over the surface of an inert material, such as that against which animals rub and transfer the
 25 material to their skins. Pour-on formulations are dispensed as a unit of liquid of small volume on to the backs of animals such that all or most of the liquid is retained on the animals.

The compounds of Formula (I) may be prepared either as formulations ready for use on the animals, plants or surface or as formulations requiring dilution prior to application, but both types of formulation comprise a compound of Formula (I) in intimate admixture with one or more carriers or diluents. The
 30 carriers may be liquid, solid or gaseous or comprise mixtures of such substances, and the compound of Formula (I) may be present in a concentration of from 0.025 to 99% w/v depending upon whether the formulation requires further dilution.

Dusts, powders and granules and other solid formulations comprise the compound of Formula (I) in intimate admixture with a powdered solid inert carrier for example suitable clays, kaolin, bentonite,
 35 attapulgite, adsorbent carbon black, talc, mica, chalk, gypsum, tricalcium phosphate, powdered cork, magnesium silicate, vegetable carriers, starch and diatomaceous earths. Such solid formulations are generally prepared by impregnating the solid diluents with solutions of the compound of formula (I) in volatile solvents, evaporating the solvents and, if desired grinding the products so as to obtain powders and, if desired, granulating, compacting or encapsulating the products.

Sprays of a compound of Formula (I) may comprise a solution in an organic solvent (e.g. those listed below) or an emulsion in water (dip wash or spray wash) prepared in the field from an emulsifiable concentrate (otherwise known as a water miscible oil) which may also be used for dipping purposes. The
 40 concentrate preferably comprises a mixture of the active ingredient, with or without an organic solvent and one or more emulsifiers. Solvents may be present within wide limits but preferably in an amount of from 0 to 90% w/v of the composition and may be selected from kerosene, ketones, alcohols, xylene, aromatic naphtha, and other solvents known in the formulating art. The concentration of emulsifiers may be varied within wide limits but is preferably in the range of 5 to 25% w/v and the emulsifiers are conveniently non-ionic surface active agents including polyoxyalkylene esters of alkyl phenols and polyoxyethylene deriva-
 45 tives of hexitol anhydrides and anionic surface active agents including Na lauryl sulphate, fatty alcohol ether sulphates, Na and Ca salts of alkyl aryl sulphonates and alkyl sulphosuccinates. Cationic emulsifiers include benzalkonium chloride and quaternary ammonium ethosulphates.

Amphoteric emulsifiers include carboxymethylated oleic imidazoline and alkyl dimethyl betain.

Vaporising mats normally comprise cotton and cellulose mix compressed into a board of approximately
 55 35 x 22 x 3mm dimensions, treated with up to 0.3ml of concentrate comprising the active ingredient in an organic solvent and optionally an antioxidant, dye and perfume. The insecticide is vaporised using a heat source such as an electrically operated mat heater.

Combustible solids normally comprise of wood powder and binder mixed with the active ingredient and formed into shaped (usually coiled) strips. Dye and fungicide may also be added.

Wettable powders comprise an inert solid carrier, one or more surface active agents, and optionally stabilisers and/or anti-oxidants.

Emulsifiable concentrates comprise emulsifying agents, and often an organic solvent, such as kerosene, ketones, alcohols, xylenes, aromatic naphtha, and other solvents known in the art.

5 Wettable powders and emulsifiable concentrates will normally contain from 5 to 95% by weight of the active ingredient, and are diluted, for example with water, before use.

Lacquers comprise a solution of the active ingredient in an organic solvent, together with a resin, and optionally a plasticiser.

10 Dip washes may be prepared not only from emulsifiable concentrates but also from wettable powders, soap based dips and aqueous suspensions comprising a compound of Formula (I) in intimate admixture with a dispersing agent and one or more surface active agents.

Aqueous suspensions of a compound of Formula (I) may comprise a suspension in water together with suspending, stabilizing or other agents. The suspensions or solutions may be applied per se or in a diluted form in known fashion.

15 Greases (or ointments) may be prepared from vegetable oils, synthetic esters of fatty acids or wool fat together with an inert base such as soft paraffin. A compound of Formula (I) is preferably distributed uniformly through the mixture in solution or suspension. Greases may also be made from emulsifiable concentrates by diluting them with an ointment base.

20 Pastes and shampoos are also semi-solid preparations in which a compound of Formula (I) may be present as an uniform dispersion in a suitable base such as soft or liquid paraffin or made on a non-greasy basis with glycerin, mucilage or a suitable soap. As greases, shampoos and pastes are usually applied without further dilution they should contain the appropriate percentage of the compound of Formula (I) required for treatment.

25 Aerosol sprays may be prepared as a simple solution of the active ingredient in the aerosol propellant and co-solvent such as halogenated alkanes and the solvents referred to above, respectively. Pour-on formulations may be made as a solution or suspension of a compound of Formula (I) in a liquid medium. An avian or mammal host may also be protected against infestation of acarine ectoparasites by means of carrying a suitably-moulded, shaped plastics article impregnated with a compound of Formula (I). Such articles include impregnated collars, tags, bands, sheets and strips suitably attached to appropriate parts of
30 the body. Suitably the plastics material is a polyvinyl chloride (PVC).

The concentration of the compound of Formula (I) to be applied to an animal, premises or outdoor areas will vary according to the compound chosen, the interval between treatments, the nature of the formulation and the likely infestation, but in general 0.001 to 20.0% w/v and preferably 0.01 to 10% of the compound should be present in the applied formulation. The amount of the compound deposited on an
35 animal will vary according to the method of application, size of the animal, concentration of the compound in the applied formulation, factor by which the formulation is diluted and the nature of the formulation but in general will lie in the range of from 0.0001% to 0.5% w/w except for undiluted formulations such as pour-on formulations which in general will be deposited at a concentration in the range from 0.1 to 20.0% and preferably 0.1 to 10%. The amount of compound to be applied to stored products in general will lie in the
40 range of from 0.1 to 20ppm. Space sprays may be applied to give an average initial concentration of 0.001 to 1mg of compound of formula (I) per cubic metre of treated space.

The compounds of formula (I) are also of use in the protection and treatment of plant species, in which case an effective insecticidal, acaricidal or nematocidal amount of the active ingredient is applied. The application rate will vary according to the compound chosen, the nature of the formulation, the mode of
45 application, the plant species, the planting density and likely infestation and other like factors but in general, a suitable use rate for agricultural crops is in the range 0.001 to 3kg/Ha and preferably between 0.01 and 1kg/Ha. Typical formulations for agricultural use contain between 0.0001% and 50% of a compound of formula (I) and conveniently between 0.1 and 15% by weight of a compound of the formula (I).

50 Dusts, greases, pastes and aerosol formulations are usually applied in a random fashion as described above and concentrations of 0.001 to 20% w/v of a compound of Formula (I) in the applied formulation may be used.

The compounds of formula (I) have been found to have activity against the common housefly (*Musca domestica*). In addition, certain compounds of formula (I) have activity against other arthropod pests including *Myzus persicae*, *Tetranychus urticae*, *Plutella xylostella*, *Culex* spp. *Tribolium castaneum*,
55 *Sitophilus granarius*, *Periplaneta americana* and *Blattella germanica*. The compounds of formula (I) are thus useful in the control of arthropods e.g. insects and acarines in any environment where these constitute pests, e.g. in agriculture, in animal husbandry, in public health control and in domestic situations.

Insect pests include members of the orders Coleoptera (e.g. *Anobium*, *Ceutorhynchus*, *Rhynchophorus*,

Cosmopolites, Lissorhoptrus, Meligethes, Hypothenemus, Hylesinus, Acalymma, Lema, Psylliodes, Lep-
 tinotarsa, Gonocephalum, Agriotes, Dermolepida, Heteronychus, Phaedon, Tribolium, Sitophilus, Diabrotica,
 Anthonomus or Anthrenus spp.), Lepidoptera (e.g. Ephestia, Mamestra, Earias, Pectinophora, Ostrinia,
 Trichoplusia, Pieris, Laphygma, Agrotis, Amathes, Wiseana, Tryporysa, Diatraea, Sparganothis, Cydia,
 5 Archips, Plutella, Chilo, Heliothis, Spodoptera or Tineola spp.), Diptera (e.g. Musca, Aedes, Anopheles,
 Culex, Glossina, Simulium, Stomoxys, Haematobia, Tabanus, Hydrotaea, Lucilia, Chrysomia, Callitroga,
 Dermatobia, Gasterophilus, Hypoderma, Hylemyia, Atherigona, Chlorops, Phytomyza, Ceratitis, Liriomyza
 and Melophagus spp.), Phthiraptera (Malophaga e.g. Damalina spp. and Anoplura e.g. Linognathus and
 Haematopinus spp.), Hemiptera (e.g. Aphis, Bemisia, Phorodon, Aeneolamia, Empoasca, Parkinsella, Pyrrilla,
 10 Aonidiella, Coccus, Pseudococcus, Helopeltis, Lygus, Dysdercus, Oxycarenus, Nezara, Aleurodes, Triatoma,
 Psylla, Myzus, Megoura, Phylloxera, Adelges, Nilaparvata, Nephrotetix or Cimex spp.), Orthoptera (e.g.
 Locusta, Gryllus, Schistocerca or Acheta spp.), Dictyoptera (e.g. Blattella, Periplaneta or Blatta spp.),
 Hymenoptera (e.g. Athalia, Cephus, Atta, Solenopsis or Monomorium spp.), Isoptera (e.g. Odontotermes and
 Reticulitermes spp.), Siphonaptera (e.g. Ctenocephalides or Pulex spp.), Thysanura (e.g. Lepisma spp.),
 15 Dermaptera (e.g. Forficula spp.), Psocoptera (e.g. Peripsocus spp.) and Thysanoptera (e.g. Thrips tabaci).

Acarine pests include ticks, e.g. members of the genera Boophilus, Ornithodoros, Rhipicephalus,
 Amblyomma, Hyalomma, Ixodes, Haemaphysalis, Dermacentor and Anocentor, and mites and manges such
 as Acarus, Tetranychus, Psoroptes, Notoednes, Sarcoptes, Psorergates, Chorioptes, Eutrombicula, De-
 modex, Panonychus, Bryobia, Eriophyes, Blaniulus, Polyphagotarsonemus, Scutigera, and Oniscus spp.

20 Nematodes which attack plants and trees of importance to agriculture, forestry, horticulture either
 directly or by spreading bacterial, viral, mycoplasma or fungal diseases of the plants, include root-knot
 nematodes such as Meloidogyne spp. (e.g. M. incognita); cyst nematodes such as Globodera spp. (e.g. G.
 rostochiensis); Heterodera spp. (e.g. H. avenae); Radopholus spp. (e.g. R. similis); lesion nematodes such
 as Pratylenchus spp. (e.g. P. pratensis); Belonolaimus spp. (e.g. B. gracilis); Tylenchulus spp. (e.g. T.
 25 semipenetrans); Rotylenchulus spp. (e.g. R. reniformis); Rotylenchus spp. (e.g. R. robustus); Helicotylenchus
 spp. (e.g. H. multicinctus); Hemicyclophora spp. (e.g. H. gracilis); Criconemoides spp. (e.g. C. similis);
 Trichodorus spp. (e.g. T. primitivus); dagger nematodes such as Xiphinema spp. (e.g. X. diversicaudatum),
 Longidorus spp. (e.g. L. elongatus); Hoplolaimus spp. (e.g. H. coronatus); Aphelenchoides spp. (e.g. A.
 rizema-bosi, A. besseyi); stem and bulb eelworms such as Ditylenchus spp. (e.g. D. dipsaci).

30 Compounds of the invention may be combined with one or more other pesticidally active ingredients
 (for example pyrethroids, carbamates and organophosphates) and/or with attractants, repellents, bac-
 teriocides, fungicides, nematocides, anthelmintics and the like. Furthermore, it has been found that the
 activity of the compounds of the invention may be enhanced by the addition of a synergist or potentiator,
 for example: one of the oxidase inhibitor class of synergists, such as piperonyl butoxide or propyl 2-
 35 propynylphenylphosphonate; a second compound of the invention; or a pyrethroid pesticidal compound.
 When an oxidase inhibitor synergist is present in a formula of the invention, the ratio of synergist to
 compound of Formula (I) will be in the range 25:1-1:25 eg about 10:1.

Stabilisers for preventing any chemical degradation which may occur with the compounds of the
 invention include, for example, antioxidants (such as tocopherols, butylhydroxyanisole and butylhydrox-
 40 ytoluene) and scavengers (such as epichlorhydrin) and organic or inorganic bases e.g. trialkylamines such
 as triethylamine which can act as basic stabilisers and as scavengers.

Formulations

45

50

55

1. Emulsifiable Concentrate

| | |
|------------------------------------|---------------|
| Compound of formula (I) | 10.00 |
| Alkyl phenol ethoxylate* | 7.50 |
| Alkyl aryl sulphonate* | 2.50 |
| C ₈₋₁₃ aromatic solvent | 80.00 |
| | <u>100.00</u> |

* = Surfactant

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| 1. Emulsifiable Concentrate | |
|------------------------------------|---------------|
| Compound of formula (I) | 10.00 |
| Alkyl phenol ethoxylate* | 2.50 |
| Alkyl aryl sulphonate* | 2.50 |
| Ketonic solvent | 64.00 |
| C ₈₋₁₃ aromatic solvent | 18.00 |
| Antioxidant | 3.00 |
| | <u>100.00</u> |

* = Surfactant

| 3. Wettable Powder | |
|------------------------------------|---------------|
| Compound of formula (I) | 5.00 |
| C ₈₋₁₃ aromatic solvent | 7.00 |
| C ₁₈ aromatic solvent | 28.00 |
| China clay | 10.00 |
| Alkyl aryl sulphonate* | 1.00 |
| Napthalene sulphonic acid* | 3.00 |
| Diatomaceous earth | 46.00 |
| | <u>100.00</u> |

* = Surfactant

| 4. Dust | |
|-------------------------|---------------|
| Compound of formula (I) | 0.50 |
| Talc | 99.50 |
| | <u>100.00</u> |

| 5. Bait | |
|-------------------------|---------------|
| Compound of formula (I) | 0.5 |
| Sugar | 79.5 |
| Paraffin wax | 20.0 |
| | <u>100.00</u> |

6. Emulsion Concentrate

| | |
|--------------------------------------|---------------|
| Compound of formula (I) | 5.00 |
| C ₈₋₁₃ aromatic solvent | 32.00 |
| Cetyl alcohol | 3.00 |
| Polyoxyethylene glycerol monooleate* | 0.75 |
| Polyoxyethylene sorbitan esters* | 0.25 |
| Silicone solution | 0.1 |
| Water | 58.9 |
| | <u>100.00</u> |

* = Surfactant

7. Suspension Concentrate

| | |
|-------------------------|---------------|
| Compound of formula (I) | 10.00 |
| Alkyl aryl ethoxylate* | 3.00 |
| Silicone solution | 0.1 |
| Alkane diol | 5.0 |
| Fumed silica | 0.50 |
| Xanthan gum | 0.20 |
| Water | 80.0 |
| Buffering agent | 1.2 |
| | <u>100.00</u> |

* = Surfactant

8. Microemulsion

| | |
|--------------------------------------|---------------|
| Compound of formula (I) | 10.00 |
| Polyoxyethylene glycerol monooleate* | 10.00 |
| Alkane diol | 4.00 |
| Water | 76.00 |
| | <u>100.00</u> |

* = Surfactant

9. Water Dispersible Granules

| | |
|-------------------------|---------------|
| Compound of formula (I) | 70.00 |
| Polyvinyl pyrrolidone | 2.50 |
| Alkyl aryl ethoxylate | 1.25 |
| Alkyl aryl sulphonate | 1.25 |
| China clay | 25.00 |
| | <u>100.00</u> |

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| 10. Granules | |
|------------------------------------|---------------|
| Compound of formula (I) | 2.00 |
| Alkyl phenol ethoxylate* | 5.00 |
| Alkyl aryl sulphonate* | 3.00 |
| C ₈₋₁₃ aromatic solvent | 20.00 |
| Kieselguhr granules | 70.00 |
| | <u>100.00</u> |

* = Surfactant

| 11. Aerosol (pressure pack) | |
|-------------------------------------------------|---------------|
| Compound of formula (I) | 0.3 |
| Piperonyl butoxide | 1.5 |
| C ₈₋₁₃ saturated hydrocarbon solvent | 58.2 |
| Butane | 40.0 |
| | <u>100.00</u> |

| 12. Aerosol (pressure pack) | |
|-------------------------------------------------|---------------|
| Compound of formula (I) | 0.3 |
| C ₈₋₁₃ saturated hydrocarbon solvent | 10.0 |
| Sorbitan monooleate* | 1.0 |
| Water | 40.0 |
| Butane | 48.7 |
| | <u>100.00</u> |

* = Surfactant

| 13. Aerosol (pressure pack) | |
|--------------------------------------|---------------|
| Compound of formula (I) | 1.00 |
| CO ₂ | 3.00 |
| Polyoxyethylene glycerol monooleate* | 1.40 |
| Propanone | 38.00 |
| Water | 56.60 |
| | <u>100.00</u> |

* = Surfactant

| 14. Lacquer | |
|----------------------------|---------------|
| Compound of formula (I) | 2.50 |
| Resin | 5.00 |
| Antioxidant | 0.50 |
| High aromatic white spirit | 92.0 |
| | <u>100.00</u> |

5

| 15. Spray (ready to use) | |
|--------------------------|---------------|
| Compound of formula (I) | 0.10 |
| Antioxidant | 0.10 |
| Odourless kerosene | 99.8 |
| | <u>100.00</u> |

10

15

| 16. Potentiated Spray (ready to use) | |
|--------------------------------------|---------------|
| Compound of formula (I) | 0.10 |
| Piperonyl butoxide | 0.50 |
| Antioxidant | 0.10 |
| Odourless kerosene | 99.30 |
| | <u>100.00</u> |

20

25

| 17. Microencapsulated | |
|------------------------------------|---------------|
| Compound of formula (I) | 10.0 |
| C ₈₋₁₃ aromatic solvent | 10.0 |
| Aromatic di-isocyanate# | 4.5 |
| Alkyl phenol ethoxylate* | 6.0 |
| Alkyl diamine# | 1.0 |
| Diethylene triamine | 1.0 |
| Concentrated hydrochloric acid | 2.2 |
| Xanthan gum | 0.2 |
| Fumed silica | 0.5 |
| Water | 64.6 |
| | <u>100.00</u> |

30

35

* = Surfactant

= react to form the polyurea walls of the microcapsule

40

Antioxidant could be any of the following individually or combined

Butylated hydroxytoluene

Butylated hydroxyanisole

Vitamin C (ascorbic acid)

45

The following examples illustrate, in a non-limiting manner, preferred aspects of the invention. All temperatures are in degrees.

50

Example 1.4-Cyclobutyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane

55

(i) Sodium (10.3g, 0.44 mmol) was dissolved in dry ethanol (300ml) under a nitrogen atmosphere and to the cooled solution (0° C) was added diethyl malonate (71g, 0.44 mmol). After stirring for 15 minutes cyclobutyl bromide (60g, 0.44 mmol) was added and the solution was heated to reflux overnight. The

cooled mixture was evaporated and the residue was partitioned between water and ether. The ether layer was separated, dried over anhydrous magnesium sulphate and evaporated. The residue was distilled to give diethyl cyclobutylmalonate (40g, 42%) (bp.74-75 °C at 0.5 mm Hg).

(ii) To a stirred solution of diethyl cyclobutylmalonate (40g, 0.19 mmol) in dry THF(100 ml) at 0 °C under nitrogen atmosphere was added carefully sodium hydride (4.8g, 0.2 mmol). The stirred mixture was allowed to warm to room temperature and was then heated to reflux for 1 hour. To the cooled solution was added benzylchloromethyl ether (31.3g, 0.2 mol) and the mixture was heated to reflux overnight. The cooled solution was partitioned between water and ether and the ether layer was separated, washed with water, dried over anhydrous magnesium sulphate and evaporated to leave diethyl 2-benzyloxymethyl-2-cyclobutylmalonate as an oil (71g) which was not purified further.

(iii) A solution of diethyl 2-benzyloxymethyl-2-cyclobutylmalonate (65g, 0.19 mol) in dry ether (50ml) was added dropwise to a stirred suspension of lithium aluminium hydride (11.5g, 0.3mol) in dry ether (200ml) at 0 °C under a nitrogen atmosphere. After the addition, the solution was heated to gentle reflux for 1 hour, allowed to cool and an excess of saturated aqueous ammonium chloride was added. Stirring was continued overnight and the resulting mixture was filtered and the solids washed with ether. The filtrate was extracted with ether, the ether extracts were combined, dried over anhydrous magnesium sulphate and evaporated to leave 2-benzyloxymethyl-2-cyclobutylpropane-1,3-diol (49g) as an oil.

(iv) A solution of 2-benzyloxymethyl-2-cyclobutylpropane-1,3-diol (49g, 0.2 mol) in dry ether (200ml) was added to liquid ammonia (450ml) stirred at -70 °C. Sodium pellets (14g, 0.6 mol) were added and the stirred mixture was allowed to warm to -33 °C over 2 hours. Ammonium chloride (35g, 0.65 mol) was added and the ammonia was allowed to evaporate overnight. The solid residue was extracted with ether, the extracts were combined, filtered and evaporated to leave 2-cyclobutyl-2-hydroxymethylpropane-1,3-diol as an oil (27.9g, 87%) which was purified on a silica column eluting with chloroform then increasing amounts of chloroform:methanol (up to 9:1 v/v).

(v) A mixture of 2-cyclobutyl-2-hydroxymethylpropane-1,3-diol (6.7g, 42 mmol), diethyl carbonate (5.5g, 46 mmol) and potassium hydroxide (0.1g in 5 ml dry ethanol) was heated to reflux under nitrogen for 15 minutes. Ethanol was then distilled off at atmospheric pressure and the residue distilled under reduced pressure. 3-Cyclobutyl-3-hydroxymethyloxetane was obtained as a colourless liquid (4.3g, 73%) bp 130-160 °C at 30 mm Hg.

(vi) To a stirred solution of 3-cyclobutyl-3-hydroxymethyloxetane (2.84g, 20 mmol) in dry dichloromethane (40ml) and pyridine (3ml) at 0 °C under nitrogen was added a solution of 4-iodobenzoyl chloride (5.33g, 20 mmol) in dry dichloromethane (10ml). The solution was stirred overnight at room temperature, washed with water, dried over anhydrous sodium sulphate and evaporated. (3-Cyclobutyloxetan-3-yl)methyl 4-iodobenzoate was obtained as a white solid (7.42g, 99%) which was not purified further.

(vii) To a stirred solution of (3-cyclobutyloxetan-3-yl)methyl 4-iodobenzoate (7.42g, 20mmol) in dry dichloromethane (80ml) at -70 °C under nitrogen atmosphere was added boron trifluoride etherate (2ml). The solution was allowed to warm to room temperature, stirred overnight and then quenched with dry triethylamine (3ml). The mixture was evaporated to dryness, partitioned between water and dichloromethane and the organic layer was separated, dried over anhydrous potassium carbonate and evaporated. The residue was chromatographed on basic alumina. Elution with hexane:dichloromethane (9:1 v/v) gave 4-cyclobutyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane (2.8g, 38%) as white crystals.

Using the above procedure and starting from hept-6-ynoyl chloride (88306718.3) instead of 4-iodobenzoyl chloride, 4-cyclobutyl-1-(hex-5-ynyl)-2,6,7-trioxabicyclo[2.2.2]octane was prepared.

Using the above methodology the following compounds were also prepared:-

- 4-Cyclopropyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane
- 1-(4-iodophenyl)-4-(trans-2-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 1-(4-iodophenyl)-4-(1-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(3-Fluorophenyl)-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(2-Fluorophenyl)-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(2-Fluorophenyl)-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane.

The required cyclopropyl malonate ester starting materials were prepared as follows:-

Cyclopropanecarbonyl chloride (36g, 0.34mol) was added dropwise to a stirred solution of ethyl diazoacetate (86.2g, 0.76mol) in dry ether (500ml) at 0 °C under a nitrogen atmosphere. The mixture was allowed to warm to room temperature then was stirred for 1 day, heated to gentle reflux for 2 days, then left to stand at room temperature for 5 days. Evaporation of the mixture followed by distillation afforded ethyl 3-cyclopropyl-2-diazo-3-oxo-propanoate (27.4g, 44%) bp 85-90 ° at 1mm Hg).

A mixture of the above diazoester (12.6g, 70mmol) and silver oxide (100mg) in anhydrous toluene (12 ml)

was heated at reflux under an atmosphere of carbon dioxide for 4 hours. The cooled solution was evaporated and the residue was distilled into a flask containing dry ethanol (15ml) cooled to -70 °C. The ketene distilled slowly, bp 70-90 °C at 1mm Hg. The ethanolic solution was allowed to warm to room temperature and was then evaporated to leave diethyl cyclopropylmalonate (9.8g, 71%) (bp 75-80 °C at 1mm Hg).

The following data for intermediate triols are also included:-

2-cyclopropyl-2-hydroxymethylpropane-1,3-diol was a colourless solid, m.pt. 57-58 °C.

2-hydroxymethyl-2-(trans 2-methylcyclopropyl)propane-1,3-diol was an oil.

2-hydroxymethyl-2-(1-methylcyclopropyl)propane-1,3-diol was a colourless solid, m.pt. 79-81 °C.

2-(3-Fluorophenyl)-2-hydroxymethylpropane-1,3-diol was prepared as follows:-

(i) To a stirred suspension of lithium aluminium hydride (25g, 0.65 mol) in dry ether (300ml) at 0 °C was added dropwise 3-fluorophenylacetic acid (50g, 0.32mol, Lancaster Synthesis). After the addition the mixture was heated to reflux for 2 hours, then stirred overnight at room temperature. Saturated aqueous ammonium chloride (200ml) was added and the mixture was filtered and the solids washed with ether. The ether layer was separated, dried over anhydrous magnesium sulphate and evaporated. Distillation of the residue afforded 2-(3-fluorophenyl)ethanol (43.05g, 95%), bp 91-94 ° at 2mmHg, NMR δ 7.3 (1H, m), 7.05-6.9 (3H, m), 3.85 (2H,t), 2.85 (2H,t), 2.0 (1H,s).

(ii) To a stirred suspension of pyridinium chlorochromate (75.5g, 0.35mol) in dry dichloromethane (300ml) under a nitrogen atmosphere was added 2-(3-fluorophenyl)ethanol (43g, 0.31mol) dropwise. After the addition the mixture was stirred for 1 hour, allowed to stand overnight then poured down a florisil column. The column was washed with ether and the combined filtrate and washings were evaporated to leave the crude 3-fluorophenyl acetaldehyde as an unstable liquid which was not purified further (34g), NMR δ 9.75 (1H, t), 7.3 (1H, m), 7.05-6.9 (3H, m), 3.7 (2H, d).

(iii) A mixture of 3-fluorophenylacetaldehyde (34g crude), formalin (250ml) and aqueous sodium hydroxide (12g in 270ml H₂O) was stirred vigorously at 50 °C for three days. The resultant solution was evaporated to dryness and the residue was washed thoroughly with isopropanol. Filtration of the isopropanol suspension followed by evaporation of the filtrate afforded a residue which was heated gradually at 0.5mmHg up to 100 °C to remove volatiles. The cooled residue was purified on a silica column and elution with chloroform-methanol (9:1 v/v) gave 2-(3-fluorophenyl)-2-hydroxymethylpropane-1,3-diol as a yellow oil (5.8g) NMR δ 7.3(3H, m), 3.95(6H, s), 3.9(3H, broad).

In an analogous manner the following intermediate triols were prepared:-

2-(2-fluorophenyl)-2-hydroxymethylpropane-1,3-diol (oil)

2-(4-fluorophenyl)-2-hydroxymethylpropane-1,3-diol (m.pt. 73-75 °C)

Example 2

3-Cyano-4-cyclobutyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane

(i) To a stirred suspension of pyridinium chlorochromate (10g, 45 mmol) in dry dichloromethane (100ml) was added 3-cyclobutyl-3-hydroxymethyloxetane (5g, 35mmol). The mixture was stirred for 2 hours, diluted with diethylether and then purified on a florisil column with an ether rinse. Evaporation afforded 3-cyclobutyl-3-formyloxetane (3.72g, 75%) as a liquid.

(ii) To a stirred solution of 3-cyclobutyl-3-formyloxetane (2.0g, 14.3 mmol) and 4-iodobenzoyl chloride (5.2g, 20 mmol) in ether (70ml) at 0 °C was added a solution of sodium cyanide (2.5g) in water (2ml). The solution was stirred at room temperature overnight, then washed with water and the organic layer was dried over anhydrous magnesium sulphate and evaporated. The residue was chromatographed on silica pre-treated with hexane containing 1% triethylamine, eluting with hexane:dichloromethane (9:1 v/v) increasing up to 3:7 v/v. 1-Cyano-1-(3-cyclobutyloxetan-3-yl) methyl 4-iodobenzoate was obtained, 2.35g, 42%.

(iii) Boron trifluoride etherate (1ml) was added to a stirred solution of 1-cyano-1-(3-cyclobutyloxetan-3-yl)methyl 4-iodobenzoate (2.3g, 5.8mmol) in dry dichloromethane (30ml) at -70 °C under a nitrogen atmosphere. The solution was allowed to warm to room temperature and was stirred overnight. Triethylamine (1ml) was added, the solution was evaporated to dryness to leave a gum which was partitioned between water and dichloromethane. The organic layer was separated, dried over anhydrous potassium carbonate and evaporated. The residue was chromatographed on basic alumina, eluting with hexane:dichloromethane (4:1 v/v) to give 3-cyano-4-cyclobutyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]-octane as a white solid (1.05g, 46%).

Using the above methodology and starting from hept-6-ynoyl chloride instead of 4-iodobenzoyl chloride, 3-cyano-4-cyclobutyl-1-(hex-5-ynyl)-2,6,7-trioxabicyclo[2.2.2]octane was prepared.

5 Example 3

4-Cyclobutyl-1-(4-prop-1-ynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane

10 A solution of 4-cyclobutyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane (Compound 1) (650mg, 1.75mmol), bis(triphenylphosphine) palladium (II) chloride (30mg) and cuprous iodide (10mg) in dry diethylamine (40ml) was stirred at room temperature. Propyne gas was bubbled through the solution for twenty minutes and stirring continued overnight. The solution was evaporated, and the residue was partitioned between water and ether. The organic layer was dried over anhydrous potassium carbonate and
15 evaporated to leave a solid which was purified on basic alumina, elution with hexane:dichloromethane (9:1 v/v) gave 4-cyclobutyl-1-(4-prop-1-ynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane as a white solid (400mg, 81%).

Using the above methodology the following compounds were also prepared:-

- 4-Cyclopropyl-1-(4-prop-1-ynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 20 4-(trans-2-Methylcyclopropyl)-1-(4-prop-1-ynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(1-Methylcyclopropyl)-1-(4-prop-1-ynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(4-Fluorophenyl)-1-(4-prop-1-ynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.

25 Example 4

4-Cyclobutyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane

30 (i) A solution of 4-cyclobutyl-1-(4-iodophenyl)-2,6,7-trioxabicyclo[2.2.2]octane (1.5g, 4mmol), trimethylsilylacetylene (1ml), bis(triphenylphosphine) palladium (II) chloride (30mg) and cuprous iodide (10mg) in dry diethylamine (30ml) under a nitrogen atmosphere was stirred overnight. The solution was evaporated and the residue partitioned between water and ether. The organic layer was dried over anhydrous magnesium sulphate and evaporated to leave 4-cyclobutyl-1-(4-trimethylsilylethynylphenyl)-2,6,7-
35 trioxabicyclo[2.2.2]octane as brown flakes (1.38g, 100%).

(ii) To a stirred solution of 4-cyclobutyl-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]-octane (Compound 2) (1.3g, 3.8mmol) in dry THF (30ml) under nitrogen atmosphere was added tetra-butylammonium fluoride (4ml of 1M solution in THF). The mixture was stirred for one hour, evaporated to dryness and the residue partitioned between water and dichloromethane. The organic layer was separated,
40 dried over anhydrous potassium carbonate and evaporated to leave a residue. Purification on a basic alumina column, eluting with hexane: dichloromethane (9:1 v/v) gave 4-cyclobutyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane as a white solid (800mg, 78%).

Using the above methodology, and starting from the appropriate 1-(4-iodophenyl)bicyclo[2.2.2]octane, the following compounds were also prepared:-

- 45 3-Cyano-4-cyclobutyl-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 3-Cyano-4-cyclobutyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-Cyclopropyl-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-Cyclopropyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(trans-2-Methylcyclopropyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 50 1-(4-Ethynylphenyl)-4-(trans-2-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(1-Methylcyclopropyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 1-(4-Ethynylphenyl)-4-(1-methylcyclopropyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(3-Fluorophenyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 1-(4-Ethynylphenyl)-4-(3-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 55 4-(2-Fluorophenyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 1-(4-Ethynylphenyl)-4-(2-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 4-(4-Fluorophenyl)-1-(4-trimethylsilylethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane.
- 1-(4-Ethynylphenyl)-4-(4-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane.

Example 51-(4-Chlorophenyl)-4-(4-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane

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A mixture of 2-(4-fluorophenyl)-2-hydroxymethylpropane-1,3-diol (1.0g, 5mmol), trimethyl 4-chloroorthobenzoate (1.1g, 5mmol) and para-toluene sulphonic acid (10mg) was heated at 140 °C until methanol no longer distilled over. The residue was purified on a basic alumina column, elution with hexane-dichloromethane (4:1 v/v) gave 1-(4-chlorophenyl)-4-(4-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane (250mg, 16%) as a white solid, (mp 251-252 °C).

10

1-(4-Chlorophenyl)-4-(2-fluorophenyl)-2,6,7-trioxabicyclo[2.2.2]octane was prepared in an analogous manner from 2-(2-fluorophenyl)-2-hydroxymethylpropane-1,3-diol.

15 Example 64-(3,4-Difluorophenyl)-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane

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(i) 3,4-Difluorobenzoyl chloride (75g, 0.43 mol - Aldrich) was added dropwise to a stirred solution of ethyl diazoacetate (100g, 0.88 mol) in dry diethyl ether (300ml) at 0 °C under a nitrogen atmosphere. The mixture was allowed to warm to room temperature then was stirred for 1 day, heated to gentle reflux for 2 days then left to stand at room temperature for 5 days. Evaporation of the mixture followed by distillation up to 45 °C (1mm Hg) removed by-products (the residue of diazoester was not distilled further but was used directly in the next stage) and ethyl 2-diazo-3-(3,4-difluorophenyl)-3-oxo-propanoate (63g, 58%) was obtained as a yellow liquid Nmr δ 7.5-7.4 (2H,m), 7.2 (1H,m), 4.25 (2H,q), 1.3 (3H,t).

25

A mixture of the above diazoester (63g, 0.25mol) and silver oxide (600mg) in anhydrous toluene (75ml) was heated to reflux under an atmosphere of carbon dioxide for 4 hours. The cooled solution was evaporated and the residue was distilled into a flask containing dry ethanol (75ml) cooled to -70 °C. The ketene distilled slowly (bp 80-135 °C, 0.5mm,Hg). The ethanol solution was allowed to warm to room temperature and was then evaporated to leave diethyl 3,4-difluorophenylmalonate as a yellow liquid (18.6g, 28%) Nmr δ 7.3 (1H,m), 7.1 (2H,m), 4.55 (1H,s), 4.2(4H,m), 1.25(6H,t).

30

(ii) To a stirred solution of diethyl 3,4-difluorophenylmalonate (13g, 48mmol) in dry tetrahydrofuran (100ml) at 0 °C under a nitrogen atmosphere was added sodium hydride (1.5g, 50mmol of 80% oil dispersion). The mixture was allowed to warm to room temperature and then heated to reflux for 1 hour. To the cooled mixture was added 4-methoxybenzyl chloromethyl ether (9.5g, 51mmol ref. Synthesis, 1983, 762) and reflux was continued overnight. The cooled mixture was partitioned between water and diethyl ether, the organic layer was separated, dried over anhydrous magnesium sulphate and evaporated to leave diethyl 2-(3,4-difluorophenyl)-2-(4-methoxybenzyloxymethyl)malonate as a yellow oil Nmr δ 7.35 (1H,m), 7.2 (2H,d), 7.15-7.00 (2H,m), 6.85 (2H,d), 4.45 (2H,s), 4.20 (4H,q), 4.10 (2H,s), 3.80 (3H,s), 1.25 (6H,t).

40

(iii) A solution of diethyl 2-(3,4-difluorophenyl)-2-(4-methoxybenzyloxymethyl) malonate (22g, 50mmol) in dry diethyl ether (50ml) was added dropwise to a stirred suspension of lithium aluminium hydride (3.8g, 100mmol) in dry diethyl ether (250ml) at 0 °C under a nitrogen atmosphere. After the addition the solution was heated to gentle reflux for 1 hour, allowed to cool and an excess of saturated aqueous ammonium chloride was added. Stirring was continued overnight and the resulting mixture was filtered and the solids washed with diethyl ether. The filtrate was extracted with diethyl ether, the ether extracts combined, dried over anhydrous magnesium sulphate and evaporated to leave 2-(3,4-difluorophenyl)-2-(4-methoxybenzyloxymethyl)propane-1,3-diol as a yellow oil (16.5g, 94%) Nmr δ 7.3-7.0 (5H,m), 6.85 (2H,d), 4.45 (2H,s), 3.9 (4H,m), 3.80 (3H,s), 3.75 (2H,s), 2.35 (2H,broad).

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(iv) 2-(3,4-Difluorophenyl)-2-(4-methoxybenzyloxymethyl)propane-1,3-diol (16.5g, 50mmol), acetone (7.5ml) and p-toluene sulphonic acid (100mg) were heated to reflux in benzene (100ml) and water was removed using Dean and Stark apparatus. After refluxing overnight the cooled solution was washed with saturated aqueous sodium bicarbonate solution and was dried over anhydrous magnesium sulphate. Evaporation gave 2,2-dimethyl-5-(3,4-difluorophenyl)-5-(4-methoxybenzyloxymethyl)-1,3-dioxane as a yellow oil (17.7g, 97%, Nmr δ 7.2-6.8 (7H,m), 4.4 (2H,s), 4.05 (2H,d), 3.95 (2H,d), 3.8 (3H,s), 3.7 (2H,s), 1.4 (6H,s).

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(v) To a stirred solution of 2,2-dimethyl-5-(3,4-difluorophenyl)-5-(4-methoxybenzyloxymethyl)-1,3-dioxane (360mg, 1mmol) in 10ml of an 18:1 v/v mixture of dichloromethane-water was added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (350mg, 1.5mmol) in small portions. The reaction mixture was stirred for 4

hours, then filtered and evaporated; purification on a silica column eluting with dichloromethane/methanol (19:1 v/v) afforded 2,2-dimethyl- 5-(3,4-difluorophenyl) 5-hydroxymethyl-1,3-dioxane as a yellow oil. Nmr δ 7.2-7.0 (3H,m), 4.05 (2H,d), 4.00 (2H,d), 4.00 (2H,s), 1.75 (1H, broad), 1.4 (6H,d).

(vi) 2,2-Dimethyl-5-(3,4-difluorophenyl)-5-hydroxymethyl-1,3-dioxane (1.0g) and Dowex 50x8-200 ion exchange resin (H^+ form) (100 mg) in methanol (100ml) containing water (20ml) was heated to reflux with stirring for 3 hours. The cooled solution was filtered and evaporated to leave 2-(3,4-difluorophenyl)-2-hydroxymethylpropane-1,3-diol (0.45g) as a yellow gum. Nmr. (d_6 acetone) δ 7.5 (1H,m), 7.3 (1H, m), 7.2 (1H,m) 3.95 (6H,s), 4.2-3.8 (3H,broad).

(vii) A mixture of trimethyl-4-bromorthobenzoate (1.3g, 5mmol) (ref. European Patent Application No.86305820.2), trimethylsilylacetylene (1g, 10mmol), palladium (II) acetate (150mg) and triphenylphosphine (300mg) in anhydrous triethylamine was heated to reflux with stirring under a nitrogen atmosphere for 1 hour. The cooled solution was evaporated to dryness, the residue partitioned between water and diethyl ether, and the organic layer was separated, dried over anhydrous magnesium sulphate and evaporated. The residue was purified on a basic alumina column, and elution with hexane afforded the trimethyl-4-trimethylsilylethynylorthobenzoate as a yellow liquid (1.2g, 87%), Nmr δ 7.5 (4H,d of d), 3.1 (9H,s), 0.25- (9H,s).

(viii) Using the procedure described in stage (ii) of Example 4, trimethyl-4-ethynylorthobenzoate was prepared as a yellow solid, mp 62-64 °C, $[M+1]^+$ 207, Nmr δ 7.5 (4H,d of d), 3.1 (9H,s), 3.1 (1H,s), from trimethyl-4-trimethylsilylethynylorthobenzoate.

(ix) A mixture of 2-(3,4-difluorophenyl)-2-hydroxymethylpropane-1,3-diol (0.45g, 2.1mmol), trimethyl 4-ethynylorthobenzoate (0.4g, 1.9mmol) and *p*-toluene- sulphonic acid (10mg) was heated at 140 °C under reduced pressure (30mm Hg) for 20 minutes. The cooled residue was purified on a basic alumina column and elution with hexane/dichloromethane (4:1 v/v) gave 4-(3,4-difluorophenyl)-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo[2.2.2]octane (250mg, 38%) as a yellow solid (mp 204-205 °C).

Example 7

1-[4-(z)-(4'-Chlorobuten-1'-ynyl)phenyl]-4-cyclobutyl-2,6,7-trioxabicyclo [2.2.2]octane

A mixture of 4-cyclobutyl-1-(4-ethynylphenyl)-2,6,7-trioxabicyclo [2.2.2] octane (500mg, 1.85mmol), cis-1,2-dichloroethylene (0.5ml), cuprous iodide (50mg), tetrakis(triphenylphosphine)palladium (O) (100mg) and *n*.butylamine (2ml) in dry benzene (30ml) under a nitrogen atmosphere was stirred at room temperature for 24 hours. The resulting solution was evaporated to dryness, the residue was taken up in dichloromethane, washed with water and then dried over anhydrous potassium carbonate. The solvents were evaporated and the residue was purified on a basic alumina column, elution with hexane-dichloro methane (9:1 v/v) gave 1-[4-(z)-(4'-chlorobuten-1'-ynyl)phenyl]-4-cyclobutyl-2,6,7-trioxabicyclo[2.2.2]octane (440mg, 72%) as white crystals mp 80-83 °C.

Example 8

1-(4-Butadiynylphenyl)-4-cyclobutyl-2,6,7-trioxabicyclo[2.2.2]octane

To a stirred solution of 1-[4-(z)-(4'-chlorobuten-1'-ynyl)phenyl]-4-cyclobutyl-2,6,7-trioxabicyclo[2.2.2]-octane (250mg, 0.76mmol) in dry tetrahydrofuran (25ml) under a nitrogen atmosphere was added tetra *n*.butyl ammonium fluoride (2.5ml of 1M solution in tetrahydrofuran). The mixture was stirred overnight, evaporated and the residue partitioned between water and dichloromethane. The organic layer was separated, dried and evaporated to leave a residue that was purified on basic alumina. Elution with hexane-dichloromethane (9:1 v/v) gave 1-(4-butadiynylphenyl)-4-cyclobutyl-2,6,7-trioxabicyclo[2.2.2]octane (180mg, 81%) as tan coloured crystals mp 123-125 °C dec.

Example 9

4-Cyclobutyl-1-(4-ethynylphenyl)-2,6-dioxo-7-thiabicyclo[2.2.2]octane

(i) 2-Cyclobutyl-2-thiomethylpropane-1,3-diol was prepared by a method analogous to that described in Example 1 stages (i) to (iv) but substituting benzylchloromethyl thioether (J.L. Wood and V.du Vigneaud, J. Biol. Chem. 1939,267) for benzylchloromethyl ether.

(ii) A mixture of 2-cyclobutyl-2-thiomethylpropane-1,3-diol (352mg, 2mmol), trimethyl-4-ethynylorthobenzoate (412mg,2mmol) and p.toluenesulphonic acid (10mg) was heated at 100 °C under reduced pressure (30mmHg) for 10 minutes. The cooled residue was purified on a basic alumina column eluting with hexane-dichloromethane (9:1 v/v) to give 4-cyclobutyl-1-(4-ethynylphenyl)-2,6-dioxo-7-thiabicyclo[2.2.2]octane (330mg, 58%) as a pale yellow solid.

10 Example 10

4-Cyclobutyl-1-(4-ethynylphenyl)-2-oxa-6,7-dithiabicyclo[2.2.2]octane

(i) To a stirred solution of 2-benzyloxymethyl-2-cyclobutylpropane-1,3-diol (41.86g, 167mmol) and pyridine (30ml, 370mmol) in dry diethyl ether (300ml) at 0 °C under nitrogen atmosphere was added methanesulphonyl chloride (27ml,350mmol). The solution was stirred overnight, poured into ice/water and extracted with diethyl ether. The ether extracts were dried over anhydrous magnesium sulphate and evaporated to leave a residue which was purified on a silica column; elution with hexane-ether (1:1 v/v) afforded 2-benzyloxymethyl-2-cyclobutylpropan-2,3-diol dimethanesulphonate (43.7g,63%) as a colourless oil.

(ii) Sodium hydride (7.5g of 80% oil dispersion, 0.25mol) was added to a stirred solution of benzylmercaptan (31g,0.25mol) in dry dimethylformamide (200ml) at 0 °C under a nitrogen atmosphere. The mixture was stirred for 30 minutes and 2-benzyloxymethyl-2-cyclobutylpropan-1,3-diol dimethanesulphonate (43.7g,0.11mol) was added and the mixture was heated at 130 °C overnight. The cooled solution was poured into ice/water and extracted with diethyl ether the ether extracts were combined, dried over anhydrous magnesium sulphate and evaporated to leave 2-benzyloxymethyl-2-cyclobutylpropane-1,3-dibenzylthioether as a crude yellow oil (53.4g).

(iii) Using the procedure to prepare 2-cyclobutyl-2-hydroxymethylpropane-1,3-diol described earlier, 2-cyclobutyl-2-hydroxymethyl propan-1,3-dithiol (11g,52%) was prepared as a pale yellow oil from 2-benzyloxymethyl-2-cyclobutylpropane-1,3-dibenzylthioether (0.11mol) and sodium (1mol).

(iv) A mixture of 2-cyclobutyl-2-hydroxymethylpropane-1,3-dithiol (600mg,3.1mmol), trimethyl-4-ethynylorthobenzoate (640mg, 3.1mmol) and p.toluene sulphonic acid (10mg) was heated at 120 °C under reduced pressure (30mmHg) for 5 minutes. The cooled residue was purified on a basic alumina column eluting with hexane then hexane-dichloromethane (9:1 v/v) to give 4-cyclobutyl-1-(4-ethynylphenyl)-2-oxa-6,7-dithiabicyclo[2.2.2]octane (200mg,21%) as a pale yellow solid.

Example 11

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4-Cyclobutyl-1-(hex-5-ynyl)-2,6,7-trithiabicyclo[2.2.2]octane

(i) To a stirred solution of 2-cyclobutyl-2-hydroxymethylpropane-1,3-diol (10g,62.5mmol) and pyridine (21ml,0.25mol) in dry chloroform (200ml) at 0 °C under nitrogen atmosphere was added methanesulphonyl chloride (25g,18ml,0.22mol). The solution was stirred overnight, poured into ice/water and extracted with chloroform. The extracts were dried over anhydrous magnesium sulphate. Evaporation afforded 2-cyclobutyl-2-hydroxymethylpropane-1,3-diol trimethanesulphonate which was not purified further. Nmr δ 4.20[6H,s], 3.05[9H,s], 2.60[1H,m], 2.10-1.70[6H,m].

(ii) Sodium hydride (7.2g of 80% oil dispersion \dagger 240mmol) was added to a stirred solution of benzylmercaptan (30g,240mmol) in dry dimethylformamide (300ml) at 0 °C under nitrogen atmosphere. The mixture was stirred for 30 minutes and then crude 2-cyclobutyl-2-hydroxymethylpropane-1,3-diol trimethanesulphonate (27.7g 62.5mmol) was added. The mixture was heated at 130 °C overnight, the cooled solution was poured into ice/water and extracted with diethyl ether. The ether extracts were combined, dried over anhydrous magnesium sulphate and evaporated to leave 2-benzylthio-methyl-2-cyclobutylpropane-1,3-dibenzylthioether as a crude yellow oil (40g) Nmr δ 7.35-7.15 [15H,m], 3.65[6H,s], 2.55[6H,s], 2.50[1H,m], 1.85-1.50[6H,m].

(iii) To liquid ammonia (1l) was added a solution of crude 2-benzylthiomethyl-2-cyclobutylpropane-1,3-dibenzylthioether (40g, 62.5mmol) in dry diethyl ether (100ml). The mixture was stirred and sodium

(16g,0.7mol) was added slowly. After the addition, stirring was continued for 3 hours, then ammonium chloride (37.5g,0.7mol) was added carefully. The ammonia was allowed to evaporate and the residue was washed thoroughly with diethyl ether. The ether washings were combined and evaporated to leave a residue which was purified on silica eluting with hexane, to give 2-cyclobutyl-2-mercaptomethylpropane-1,3-dithiol as an oil (10.2g,78%) Nmr δ 2.65[6H,d], 2.05-1.60[7H,m], 1.25[3H,t].

(iv) A mixture of 2-cyclobutyl-2-mercaptomethylpropane-1,3-dithiol (4g,20mmol), trimethylorthoformate (2.5g,24mmol) and Amberlyst 15 ion-exchange resin (1g) was heated to reflux with stirring under a nitrogen atmosphere for 1 hour in dry benzene (100ml). The mixture was filtered and evaporated to leave a residue which was washed with diethyl ether to give 4-cyclobutyl-2,6,7-trithiabicyclo[2.2.2]octane as a white solid (1.8g,43%) mp 112-114 °C, $[M + 1]^+$ 219.

(v) To a solution of 4-cyclobutyl-2,6,7-trithiabicyclo[2.2.2]octane (2g,9.2mmol) in dry tetrahydrofuran (50ml) at -70 °C under a nitrogen atmosphere was added n.butyl lithium (4ml,9.2mmol,2.3M solution in hexane). After stirring for 1 hour 1-trimethylsilyl-6-iodohex-1-yne(2.6g,9.3mmol) (ref.European Patent Application No. 88306718.3) was added. Stirring was continued for one hour and the mixture was allowed to warm to room temperature. After pouring into ice/water the mixture was extracted with diethyl ether, the organic layer was separated, dried over anhydrous magnesium sulphate and evaporated to give 4-cyclobutyl-1-(6-trimethylsilylhex-5-ynyl)-2,6,7-trithiabicyclo[2.2.2]octane as a white solid which was recrystallised from hexane-dichloromethane (3.2g,94%).

(vi) To a stirred solution of 4-cyclobutyl-1-(6-trimethylsilylhex-5-ynyl)-2,6,7-trithiabicyclo[2.2.2]octane (1.1g,3mmol) in dry tetrahydrofuran, (40ml) was added tetra n-butylammonium fluoride (3.2ml of 1M solution in tetrahydrofuran). The mixture was stirred under a nitrogen atmosphere for 1 hour, evaporated and the residue partitioned between water and dichloromethane. The organic layer was separated, dried over anhydrous potassium carbonate and evaporated to leave a solid which was purified by chromatography on silica. 4-Cyclobutyl-1-(hex-5-ynyl)-2,6,7-trithiabicyclo[2.2.2]octane was obtained as a colourless solid.

BIOLOGICAL ACTIVITIES

The following examples illustrate in a non-limiting manner, the pesticidal activity of compounds of formula (I)

Spray Tests

The compounds of the invention were tested by dissolving the compounds in acetone (5%) and then diluting in water: 'Symperonic' (94.5%: 0.5%) to give a water emulsion. The solution was then used to treat the following insects.

Musca domestica:

20 female Musca were contained in a cardboard cylinder with gauze over either end. Solution containing the compound was sprayed onto the insects so enclosed and mortality assessed after 48 hours at 25 °C.

The following compounds were active at < 1000 ppm:

1, 5, 14, 29, 30

The following compounds were active at < 200 ppm:

2, 3, 4, 9, 10, 11, 12, 13, 15, 16, 17,18, 19, 20, 21, 25, 27, 28, 33, 34

Sitophilus granarius and Tribolium castaneum:

20 adult Sitophilus and Tribolium were added to 10g wheat which had been previously treated with 2ml of the solution containing the compound. Mortality was assessed after 6 days at 25 °C.

Sitophilus

The following compounds were active at < 1000 ppm:

2, 5, 13, 18, 19, 27, 29, 30

The following compounds were active at <200 ppm:

3, 4, 9, 11, 12, 16, 17, 20, 21, 22, 24, 28, 34

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Tribolium

The following compounds were active at <1000 ppm:

1, 3, 5, 12, 17, 29, 30

10 The following compounds were active at <200 ppm:

16, 20, 21, 28

Plutella xylostella

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7 Plutella larvae were sprayed with the solution containing the compound and added to a chinese cabbage leaf which had been similarly sprayed and left to dry. Alternatively 7 Plutella larvae were put onto leaf discs and sprayed with the solution containing the compound. Mortality was assessed after 2 days at 25 °C.

20 The following compounds were active at <1000 ppm:

5, 9, 17, 29, 34

The following compounds were active at <200 ppm:

3, 4, 16, 20, 21, 28, 30, 33

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Myzus persicae

10 adult Myzus were placed on a leaf disc of chinese cabbage. 24 Hours later the disc was sprayed with the solution containing the compound. Mortality was assessed after 2 days at 20 °C.

30 The following compounds were active at <1000 ppm:

3, 5, 20, 33

The following compounds were active at < 200 ppm:

4, 9

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Tetranychus urticae

Leaf discs of infested french bean were sprayed with the solution containing the compound. Mortality was assessed after 2 days at 25 °C.

40 The following compounds were active at <1000 ppm:

10, 12, 13, 20

The following compounds were active at <200 ppm:

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Spodoptera littoralis

A chinese cabbage leaf was sprayed with the solution of the compound and left to dry. It was infested with 10 newly hatched Spodoptera larvae. Mortality was assessed after 3 days at 25 °C.

50 The following compounds were active at less than 200p.p.m.:-

33

Diabrotica Undecimpunctata

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Filter paper and food were sprayed and subsequently infested with 10 second instar larvae. Mortality was assessed after 48 hours.

The following compounds were active at less than 200p.p.m.:-

33

Topical Application

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The activity of compounds of the invention against anaesthetised male Blatella germanica was demonstrated by the topical application to the test insect of a solution of the compound under test in butanone. Mortality was assessed after 6 days.

The following compounds were active at <5µg per insect

10 9, 16, 18, 20, 21, 28, 30, 33

Anaesthetised adult male Periplaneta americana were topically applied with a solution of the compound under test in butanone. Mortality was assessed after 6 days. The following compounds were active at less than 5µg/insect:-

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The activity of compounds of the invention against unanaesthetised female Musca domestica (WRL strain), was demonstrated by the topical application to the test insect of a solution of the compound under test in butanone. Mortality was assessed at 48 hours.

The following compounds were active at <5µg per insect:

2, 3, 4, 8, 9, 12, 13, 15, 16, 17, 19, 20, 21, 25, 27, 28, 30, 33, 34

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TABLE 1

2,6,7-Trioxabicyclo(2.2.2) octanes

| Compound Number | R | R ¹ | R ³ | Synthetic Method |
|--------------------|-------------|----------------|------------------------------------|---------------------|
| 1. | Cyclobutyl | H | 4-Iodophenyl | 1 |
| 2. | Cyclobutyl | H | 4-Trimethylsilyl- ethynylphenyl | 4 |
| 3. | Cyclobutyl | H | 4-(Propyl-1-ynyl)phenyl | 3 |
| 4. | Cyclobutyl | H | 4-Ethynylphenyl | 4 |
| 5. | Cyclobutyl | H | Hex-5-ynyl | 1 |
| 6. | Cyclobutyl | CN | 4-Iodophenyl | 2 |
| 7. | Cyclobutyl | CN | 4-Trimethylsilyl- ethynylphenyl | 4 |
| 8. | Cyclobutyl | CN | 4-Ethynylphenyl | 4 |
| 9. | Cyclobutyl | CN | Hex-5-ynyl | 2 |
| 10. | Cyclopropyl | H | 4-Iodophenyl | 1 |

| Compound Number | R | R ¹ | R ³ | Synthetic Method |
|--------------------|------------------------------------|----------------|--------------------------------|---------------------|
| 11. | Cyclopropyl | H | 4-Trimethylsilylethynyl-phenyl | 4 |
| 12. | Cyclopropyl | H | 4-Ethynylphenyl | 4 |
| 13. | Cyclopropyl | H | 4-(Prop-1-ynyl)phenyl | 3 |
| 14. | <u>trans</u> -2-Methyl-cyclopropyl | H | 4-Iodophenyl | 1 |
| 15. | <u>trans</u> -2-Methyl-cyclopropyl | H | 4-Trimethylsilylethynyl-phenyl | 4 |
| 16. | <u>trans</u> -2-Methyl-cyclopropyl | H | 4-Ethynylphenyl | 4 |
| 17. | <u>trans</u> -2-Methyl-cyclopropyl | H | 4-(Prop-1-ynyl)-phenyl | 3 |
| 18. | 1-Methylcyclo-propyl | H | 4-Iodophenyl | 1 |
| 19. | 1-Methylcyclo-propyl | H | 4-Trimethylsilylethynyl-phenyl | 4 |
| 20. | 1-Methylcyclo-propyl | H | 4-Ethynylphenyl | 4 |

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| Compound Number | R | R ¹ | R ³ | Synthetic Method |
|--------------------|--------------------------|----------------|------------------------------------|---------------------|
| 21. | 1-Methylcyclo- propyl | H | 4-(Prop-1-ynyl)- phenyl | 3 |
| 22. | 3-Fluorophenyl | H | 4-Iodophenyl | 1 |
| 23. | 2-Fluorophenyl | H | 4-Iodophenyl | 1 |
| 24. | 4-Fluorophenyl | H | 4-Iodophenyl | 1 |
| 25. | 3-Fluorophenyl | H | 4-Trimethylsilylethynyl- phenyl | 4 |
| 26. | 2-Fluorophenyl | H | 4-Trimethylsilylethynyl- phenyl | 4 |
| 27. | 4-Fluorophenyl | H | 4-Trimethylsilylethynyl- phenyl | 4 |
| 28. | 3-Fluorophenyl | H | 4-Ethynylphenyl | 4 |
| 29. | 2-Fluorophenyl | H | 4-Ethynylphenyl | 4 |
| 30. | 4-Fluorophenyl | H | 4-Ethynylphenyl | 4 |
| 31. | 4-Fluorophenyl | H | 4-Chlorophenyl | 5 |
| 32. | 2-Fluorophenyl | H | 4-Chlorophenyl | 5 |
| 33. | 3,4-Difluorophenyl | H | 4-Ethynylphenyl | 6 |

| Compound Number | R | R ¹ | R ³ | Synthetic Method |
|--------------------|----------------|----------------|--------------------------------------|---------------------|
| 34. | 4-Fluorophenyl | H | 4-(Prop-1-ynyl)phenyl | 3 |
| 35. | Cyclobutyl | H | z-4-(4-Chlorobuten-1-ynyl) phenyl | 7 |
| 36. | Cyclobutyl | H | 4-Butadiynynlphenyl | 8 |

TABLE 2 Characterising Data for 2,6,7-Trioxabicyclo[2.2.2]octanes

| Compound Number | Melting Point | Mass Spectrum Chemical Ionisation M+1 | Nuclear Magnetic Resonance Spectrum ¹ H, in CDCl ₃ , p.p.m. from TMS, number protons, multiplicity. |
|-----------------|---------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| 1. | 162-3° | 373 | 7.7,2H,d; 7.3,2H,d; 4.1,6H,s; 2.25,1H,m; 1.9-1.7,6H,m. |
| 2. | 174-6° | 343 | 7.55,2H,d; 7.4,2H,d; 4.1,6H,s; 2.25,1H,m; 1.9-1.7,6H,m; 0.2,9H,s. |
| 3. | 202-203° | 285 | 7.5,2H,d; 7.35,2H,d; 4.1,6H,s; 2.25,1H,m; 2.0,3H,s; 1.9-1.7,6H,m. |
| 4. | 162-163° | 271 | 7.55,2H,d; 7.45,2H,d; 4.1,6H,s; 3.05,1H,s; 2.25,1H,m; 1.9- 1.7,6H,m. |
| 5. | 26-27° | 251 | 3.85,6H,s; 2.15,3H,m; 1.9,1H,t; 1.85-1.5, 12H,m. |
| 6. | 120-121° | 398 | 7.7,2H,d; 7.3,2H,d; 4.8,1H,d; 4.4,1H,dd; 4.25,1H,d; 4.15,1H,dd; 4.05,1H,dd; 2.5,1H,m; 2.0-1.7,6H,m. |
| 7. | Solid | | 7.5,2H,d; 7.4,2H,d; 4.8,1H,d; 4.4,1H,dd; 4.25,1H,d; 4.15,1H,dd; 4.05,1H,dd; 2.5,1H,m; 2.0-1.7,6H,m; 0.25,9H,s. |
| 8. | 98-99° | 296 | 7.55,2H,d; 7.45,2H,d; 4.80,1H,d; 4.4,1H,dd; 4.25,1H,d; 4.15,1H,dd; 4.05,1H,dd; 3.1,1H,s; 2.5,1H,m; 2.0-1.7,6H,m. |

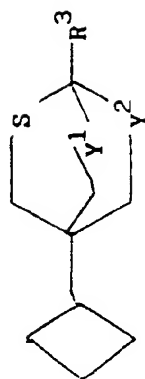
| Compound Number | Melting Point | Mass Spectrum Chemical Ionisation M+1 | Nuclear Magnetic Resonance Spectrum 1H, in CDCl ₃ , p.p.m. from TMS, number protons, multiplicity. |
|--------------------|------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| 9. | 50-51° | 276 | 4.65, 1H, d; 4.25, 1H, dd; 4.05, 1H, d; 3.95, 1H, dd; 3.85, 1H, dd; 2.4, 1H, m; 2.15, 2H, m; 2.0-1.5, 13H, m. |
| 10. | 175-177 | 359 | 7.65, 2H, d; 7.3, 2H, d; 4.0, 6H, s; 0.55, 1H, m; 0.45, 2H, m; 0.25, 2H, m. |
| 11. | 189-191 | 329 | 7.55, 2H, d; 7.4, 2H, d; 4.0, 6H, s; 0.55, 1H, m; 0.45, 2H, m; 0.25, 2H, m; 0.2, 9H, s. |
| 12. | 180-182 | 257 | 7.55, 2H, d; 7.45, 2H, d; 4.0, 6H, s; 3.05, 1H, s; 0.55, 1H, m; 0.45, 2H, m; 0.25, 2H, m. |
| 13. | 185-187° | 271 | 7.5, 2H, d; 7.35, 2H, d; 4.0, 6H, s; 2.0, 3H, s; 0.55, 1H, m; 0.45, 2H, m; 0.25, 2H, m. |
| 14. | 129-131° | 373 | 7.65, 2H, d; 7.3, 2H, d; 4.0, 6H, s; 1.0, 3H, d; 0.65, 1H, m; 0.4, 1H, m; 0.2, 2H, m. |
| 15. | 139-141° | 343 | 7.5, 2H, d; 7.4, 2H, d; 4.0, 6H, s; 1.0, 3H, d; 0.65, 1H, m; 0.4, 1H, m; 0.2, 2H, m; 0.2, 9H, s. |
| 16. | 128-131° | 271 | 7.55, 2H, d; 7.45, 2H, d; 4.0, 6H, s; 3.05, 1H, s; 1.0, 3H, d; 0.65, 1H, m; 0.45, 1H, m; 0.2, 2H, m. |
| 17. | 194-196° | 285 | 7.5, 2H, d; 7.35, 2H, d; 4.0, 6H, s; 2.0, 3H, s; 1.0, 3H, d; 0.65, 1H, m; 0.4, 1H, m; 0.2, 2H, m. |

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| Compound Number | Melting Point | Mass Spectrum Chemical Ionisation M+1 | Nuclear Magnetic Resonance Spectrum ¹ H, in CDCl ₃ , p.p.m. from TMS, number protons, multiplicity. |
|--------------------|------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 18. | 185-187° | 373 | 7.65,2H,d; 7.3,2H,d; 4.05,6H,s; 1.0,3H,s; 0.5,2H,m; 0.2,2H,m. |
| 19. | 235-237° | 343 | 7.5,2H,d; 7.4,2H,d; 4.05,6H,s; 1.0,3H,s; 0.5,2H,m; 0.2,2H,m; 0.2,9H,s. |
| 20. | 139-142° | 271 | 7.55,2H,d; 7.45,2H,d; 4.05,6H,s; 3.05,1H,s; 1.0,3H,s; 0.5,2H,m; 0.2,2H,m. |
| 21. | 195-198 | 285 | 7.5,2H,d; 7.35,2H,d; 4.05,6H,s; 2.0,3H,s; 1.0,3H,s; 0.5,2H,m; 0.2,2H,m. |
| 22. | 186-7° | 413 | 7.7,2H,d; 7.4,2H,d; 7.35,1H,m; 7.1-6.85,3H,m; 4.45,6H,s. |
| 23. | 158-161° | 413 | 7.7,2H,d; 7.4,2H,d; 7.35-7.0,4H,m; 4.55,6H,s. |
| 24. | 269-271° | 413 | 7.7,2H,d; 7.4,2H,d; 7.2-7.05,4H,m; 4.45,6H,s. |
| 25. | | 383 | 7.6,2H,d; 7.45,2H,d; 7.35,1H,m; 7.1-6.85,3H,m; 4.45,6H,s; 0.2,9H,s. |
| 26. | 208-9° | 383 | 7.6,2H,d; 7.45,2H,d; 7.35-7.0,4H,m; 4.55,6H,s; 0.25,9H,s. |
| 27. | 266-268° | 383 | 7.6,2H,d; 7.45,2H,d; 7.2-7.05,4H,m; 4.45,6H,s; 0.25,9H,s. |

| Compound Number | Melting Point | Mass Spectrum Chemical Ionisation M+1 | Nuclear Magnetic Resonance Spectrum ¹ H, in CDCl ₃ , p.p.m. from TMS, number protons, multiplicity. |
|--------------------|--------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 28. | 193-194° | 311 | 7.6,2H,d; 7.5,2H,d; 7.35,1H,m; 7.1-6.85,3H,m; 4.45,6H,s; 3.1,1H,s. |
| 29. | 163-165° | 311 | 7.6,2H,d; 7.5,2H,d; 7.3,1H,m; 7.2-7.0,3H,m; 4.55,6H,s; 3.1,1H,s. |
| 30. | 239-241° | 311 | 7.6,2H,d; 7.5,2H,d; 7.2-7.05,4H,m; 7.45,6H,s; 3.1,1H,s. |
| 31. | 251-252° | 321 | 7.6,2H,d; 7.3,2H,d; 7.2-7.05,4H,m; 4.4,6H,s. |
| 32. | 185-187° | 321 | 7.6,2H,d; 7.3,2H,d; 7.3,1H,m; 7.2-7.0,3H,m; 4.55,6H,s. |
| 33. | 204-205° | 329 | 7.6,2H,d; 7.5,2H,d; 7.2,1H,m; 7.0,1H,m; 6.9,1H,m; 4.40,6H,s; 3.1,1H,s. |
| 34. | 276-278° | 325 | 7.55,2H,d; 7.40,2H,d; 7.20-7.05,4H,m; 4.45,6H,s; 2.05,3H,s. |
| 35. | 80-83° | 331 | 7.5,2H,d; 7.45,2H,d; 6.4,1H,d; 6.05,1H,d; 4.1,6H,s; 2.25,1H,m; 1.95-1.7,6H,m. |
| 36. | 123-125° (decomposes) | 295 | 7.55,2H,d; 7.5,2H,d; 4.1,6H,s; 2.5,1H,s; 2.2,1H,m; 1.95-1.70,6H,m. |

AJR/EB/19th December, 1989.

TABLE 3 Thiabicyclo-octanes

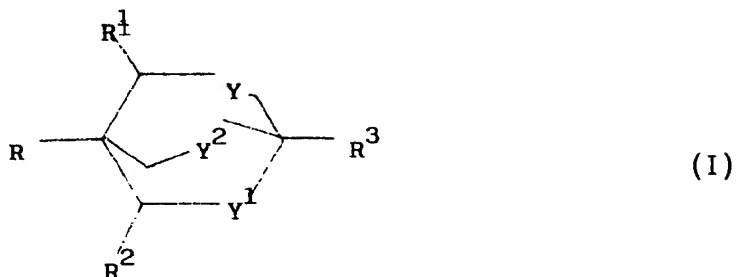
| Compound Number | R ³ | Y ¹ | Y ² | Synthetic Method |
|--------------------|---------------------------------|----------------|----------------|---------------------|
| 37. | 4-Ethynylphenyl | O | O | 9 |
| 38. | 4-Ethynylphenyl | S | O | 10 |
| 39. | 6-Trimethylsilyl- hex-5-ynyl | S | S | 11 |
| 40. | Hex-5-ynyl | S | S | 11 |

TABLE 4

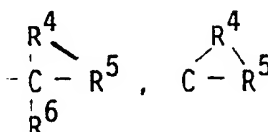
| Characterising Data for Thiabicyclo-octanes | | | |
|---------------------------------------------|---------------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Compound Number | Melting Point | Mass Spectrum Chemical Ionisation M + 1 | Nuclear Magnetic Resonance Spectrum ¹ H, in CDCl ₃ , p.p.m. from TMS, number of protons, multiplicity. |
| 37. | 163-5° | 287 | 7.55,2H,d; 7.45,2H,d; 4.15,4H,dd; 3.05,1H,s; 3.0,2H,s; 2.25,1H,m; 1.9-1.7,6H m. |
| 38. | 141-143° | 303 | 7.6,2H,d; 7.45,2H,d; 4.15,2H,s; 3.1,4H,s; 3.05,1H,s; 2.3,1H,m; 1.95-1.7,6H,m. |
| 39. | 130-132° | 371 | 2.95,6H,s; 2.35,1H,m; 2.25,2H,t; 2.00,2H,m; 1.95-1.55,10H,m; 0.13,9H,s. |
| 40. | 70-71° | 299 | 2.95,6H,s; 2.35,1H,m; 2.20,2H,dt; 2.00,2H,m; 1.93,1H,t; 1.90-1.50,10H,m. |

Claims

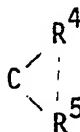
1) A compound of the formula (I):



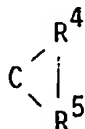
wherein R is a phenyl group, substituted by 1 to 5 fluorine atoms and optionally substituted at the para position by methyl or chloro or R is a group



being a three or four membered ring, where R⁴ is oxygen or a group CR⁷R⁸ wherein groups R⁷, R⁸ are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, and when



is a three-membered ring R⁵ is a group CR^{7a}R^{8a} wherein R^{7a}, R^{8a} are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, or when



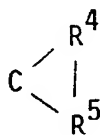
is a four membered ring R⁵ is a group CR^{7a}R^{8a}CR⁹R¹⁰ wherein R^{7a}, R^{8a} are as hereinbefore defined and R⁹ and R¹⁰ are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms; R⁶ is hydrogen, fluoro, chloro or methyl;

R¹ and R² may be the same or different, and each is hydrogen, halo, or a C₁₋₃ aliphatic group optionally substituted by halo, cyano, C₂₋₅ carbalkoxy, C₁₋₄ alkoxy, or a group S(O)_m R¹¹ wherein m is 0, 1 or 2 and R¹¹ is C₁₋₄ alkyl; cyano, gem dimethyl, or C₂₋₅ carbalkoxy; R³ contains between 3 and 18 carbon atoms and is a group R¹² wherein R¹² is a C₁₋₁₃ non-aromatic hydrocarbyl group, optionally substituted by a C₂₋₄ carbalkoxy or cyano group and/or by one or two hydroxy groups and/or by one to five halo atoms which are the same or different and/or by one to three groups R¹³ which are the same or different and each contains one to four hetero atoms, which are the same or different and are chosen from oxygen, sulphur, nitrogen

and silicon, 1 to 10 carbon atoms and optionally 1 to 6 fluoro or chloro atoms or R^3 is a 6-membered aromatic ring substituted by cyano and/or by one to five halo atoms and/or by one to three C_{1-4} haloalkyl groups and/or by a group $-C\equiv CH$, $C\equiv C$ -halo or $-C\equiv C-R^{12}$ wherein R^{12} is as hereinbefore defined or $-C\equiv C-R^{14}$ wherein R^{14} is a group $S(O)_q R^{15}$ wherein R^{15} is methyl, ethyl or trifluoromethyl or R^{14} is $SiR^{16}R^{17}R^{18}$ wherein R^{15} and R^{17} are the same or different and are each C_{1-4} aliphatic groups and R^{18} is a C_{1-4} aliphatic group or phenyl provided that R^{16} , R^{17} and R^{18} do not contain more than 10 carbon atoms in total; and Y , Y^1 and Y^2 are the same or different and are each selected from oxygen and $S(O)_t$ where t is 0, 1 or 2.

2) A compound according to claim 1 wherein R is a phenyl group substituted by 1 to 5 fluorine atoms and optionally substituted at the para position by methyl or chloro.

3) A compound according to claim 1 wherein R is a group



as hereinbefore defined.

4) A compound according to any one of claims 1 to 3 wherein R^1 is hydrogen, cyano, methyl or ethyl each optionally substituted by cyano, methoxy, methylthio, chloro, bromo or fluoro.

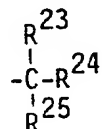
5) A compound according to any one of claims 1 to 4 wherein R^2 is hydrogen, cyano, methyl or trifluoromethyl.

6) A compound according to any one of claims 1 to 5 wherein R^3 is a phenyl group substituted at the 3-, 4- or 5-positions by one to three substituents each selected from halo, C_{1-4} haloalkyl, cyano, or a group $(C\equiv C)_p R^{20}$ wherein p is 1 or 2 and R^{20} is hydrogen, bromo, chloro or iodo; or R^{20} is an aliphatic group containing up to five carbon atoms optionally substituted by C_{1-4} alkoxy, C_{1-6} alkoxyalkoxy, C_{1-8} acyloxy, halo or hydroxy; or R^{20} is $SiR^{16}R^{17}R^{18}$ wherein R^{16} and R^{17} and R^{18} are as hereinbefore defined and the phenyl group is additionally optionally substituted at the 2- and/or 6-positions by fluoro or chloro.

7) A compound according to any one of claims 1 to 6 wherein R^3 is phenyl substituted at the 3-, 4- or 5- positions by one to three substituents each selected from halo, cyano, C_{1-4} haloalkyl or a group $C\equiv C-R^{21}$ where R^{21} is hydrogen, methyl, or ethyl each optionally substituted by hydroxy, methoxy, ethoxy, acetoxy; or R^{21} is ethynyl, or a silyl group substituted by three C_{1-4} alkyl groups, R^3 is additionally optionally substituted at the 2- and/or 6- positions by fluoro or chloro.

8) A compound according to any one of claims 1 to 5 wherein R^3 is a group $-B(C\equiv C)Z$, wherein B is a C_{3-5} aliphatic chain optionally containing a double bond and/or an oxygen atom and/or a group $S(O)_q$ wherein q is 0, 1 or 2, and optionally substituted by halo, C_{1-4} alkyl, C_{1-4} haloalkyl, C_{2-4} carbalkoxy or cyano and Z is hydrogen, C_{1-5} alkyl, C_{1-3} alkoxymethyl or a group $SiR^{16}R^{17}R^{18}$ wherein R^{16} , R^{17} and R^{18} are as hereinbefore defined.

9) A compound according to any one of claim 1 to 5 wherein R^3 is a group $-DZ^1$, wherein D is a group $-CH_2O-$ or $CH_2S(O)_q$ wherein q is 0, 1 or 2 or a C_{2-3} aliphatic group each of which may be optionally substituted by one to three halo atoms and Z^1 is silyl substituted by three C_{1-4} alkyl groups or Z^1 is a group

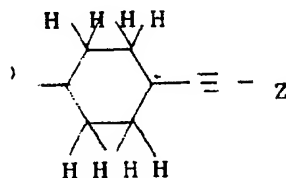


wherein R^{23} , R^{24} and R^{25} are the same or different and are each independently selected from halo, cyano, C_{2-5} carbalkoxy, or a C_{1-4} aliphatic group optionally substituted by halo, cyano, C_{2-5} carbalkoxy, C_{1-4} alkoxy or a group $S(O)_q R^{26}$ wherein q is 0, 1 or 2 and R^{26} is C_{1-4} alkyl, or R^{23} , R^{24} and R^{25} are selected from C_{1-4} alkoxy or a group $S(O)_z R^{27}$ wherein z is 0, 1 or 2 and R^{27} is C_{1-4} alkyl optionally substituted by fluoro or R^{23} and R^{24} are linked to form a C_{3-6} cycloalkyl ring, or one of R^{23} , R^{24} and R^{25} may be

hydrogen.

10) A compound of the formula (I) wherein R^3 is a group

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wherein Z is as hereinbefore defined:

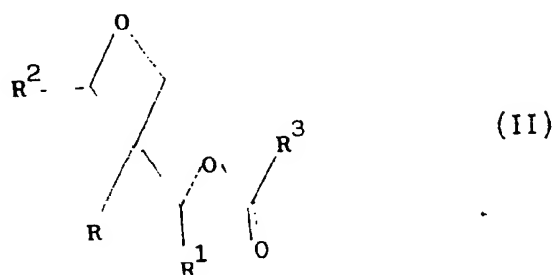
11) A process for the preparation of a compound of the formula (I) according to any one of claims 1 to 10, which comprises:

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(i) when Y, Y^1 and Y^2 are oxygen:

by the cyclisation of a compound of the formula (II) :

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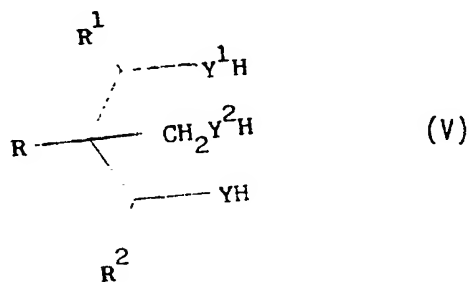
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wherein R to R^3 are as hereinbefore defined, in the presence of an acid catalyst,

(ii) when Y, Y^1 and Y^2 are each oxygen or sulphur,

by the reaction of a compound of the formula (V) with a compound of the formula $(AlkO)_3CR^3$

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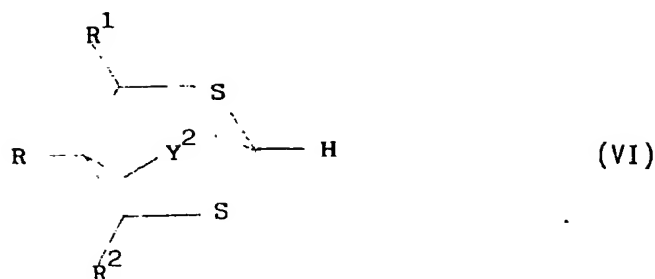
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wherein R to R^3 , Y, Y^1 and Y^2 are as hereinbefore defined and Alk is a C_1-4 alkyl group.

(iii) when Y^2 = sulphur or oxygen and Y and Y^1 are sulphur by reaction of a compound of the formula (VI)

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with a compound L^1R^3 wherein R to R^3 , are as hereinbefore defined, Y^2 is sulphur or oxygen and L^1 is a leaving group eg.halo,

(iv) By the interconversion of compounds of the formula (I),

12) An insecticidal or acaricidal composition comprising a compound of formula (I) as defined in any one of claims 1-10 in admixture with a carrier or diluent.

13) A synergised pesticidal composition comprising a compound of formula (I), as defined in any one of claims 1-10, a synergist for the formula (I) compound and a carrier or diluent.

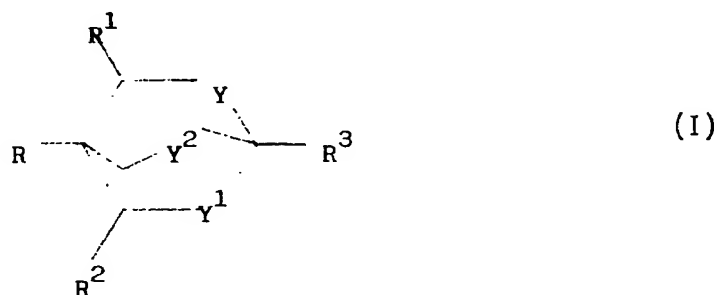
14) A mixture of a compound of formula (I) as defined in any one of claims 1-10 and another pesticidal compound.

15) A method for the control of pests comprising application to the pest or to an environment susceptible to pest infestation of a pesticidally effective amount of a compound according to any one of claims 1-10 or a composition or mixture according to any one of claims 12-14.

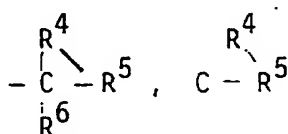
16) A compound as defined in any one of claims 1-10 or composition according to any one of claims 12-14 for use in a method of surgery or therapy practised on the human or animal body or in a method of diagnosis practised on the human or animal body.

Claims for the following Contracting State: ES, GR

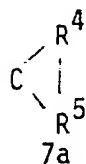
1) A process for the preparation of a compound of the formula (I):



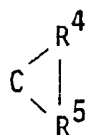
wherein R is a phenyl group, substituted by 1 to 5 fluorine atoms and optionally substituted at the para position by methyl or chloro or R is a group



being a three or four membered ring, where R^4 is oxygen or a group CR^7R^8 wherein groups R^7 , R^8 are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, and when



is a three-membered ring R⁵ is a group CR^{7a}R^{8a} wherein R^{7a}, R^{8a} are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms, or when

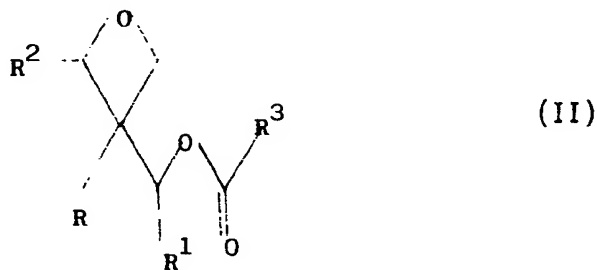


is a four membered ring R⁵ is a group CR^{7a}R^{8a}CR⁹R¹⁰ wherein R^{7a}, R^{8a} are as hereinbefore defined and R⁹ and R¹⁰ are the same or different and each is hydrogen, fluoro, chloro or bromo or methyl or ethyl optionally substituted by 1 to 3 fluoro atoms; R⁵ is hydrogen, fluoro, chloro or methyl;

R¹ and R² may be the same or different, and each is hydrogen, halo, or a C₁₋₃ aliphatic group optionally substituted by halo, cyano, C₂₋₅ carbalkoxy, C₁₋₄ alkoxy, or a group S(O)_m R¹¹ wherein m is 0, 1 or 2 and R¹¹ is C₁₋₄ alkyl; cyano, gem dimethyl, or C₂₋₅ carbalkoxy; R³ contains between 3 and 18 carbon atoms and is a group R¹² wherein R¹² is a C₁₋₁₃ non-aromatic hydrocarbyl group, optionally substituted by a C₂₋₄ carbalkoxy or cyano group and/or by one or two hydroxy groups and/or by one to five halo atoms which are the same or different and/or by one to three groups R¹³ which are the same or different and each contains one to four hetero atoms, which are the same or different and are chosen from oxygen, sulphur, nitrogen and silicon, 1 to 10 carbon atoms and optionally 1 to 6 fluoro or chloro atoms or R³ is a 6-membered aromatic ring substituted by cyano and/or by one to five halo atoms and/or by one to three C₁₋₄ haloalkyl groups and/or by a group -C≡CH, C≡C-halo or -C≡C-R¹² wherein R¹² is as hereinbefore defined or -C≡C-R¹⁴ wherein R¹⁴ is a group S(O)_qR¹⁵ wherein R¹⁵ is methyl, ethyl or trifluoromethyl or R¹⁴ is SiR¹⁶R¹⁷R¹⁸ wherein R¹⁶ and R¹⁷ are the same or different and are each C₁₋₄ aliphatic groups and R¹⁸ is a C₁₋₄ aliphatic group or phenyl provided that R¹⁶, R¹⁷ and R¹⁸ do not contain more than 10 carbon atoms in total; and Y, Y¹ and Y² are the same or different and are each selected from oxygen and S(O)_t where t is 0, 1 or 2, which process comprises:

(i) when Y, Y¹ and Y² are oxygen;

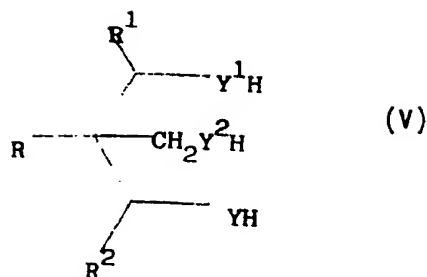
by the cyclisation of a compound of the formula (II) :



wherein R to R³ are as hereinbefore defined, in the presence of an acid catalyst,

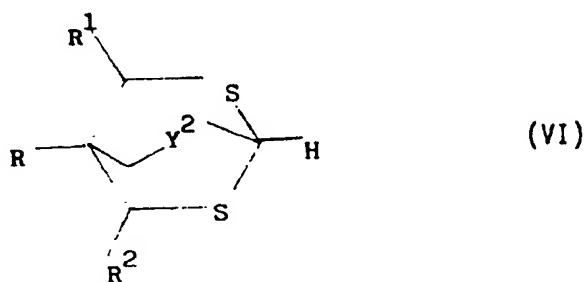
(ii) when Y, Y¹ and Y² are each oxygen or sulphur,

by the reaction of a compound of the formula (V) with a compound of the formula (AlkO)₃CR³



wherein R to R³, Y, Y¹ and Y² are as hereinbefore defined and Alk is a C₁₋₄ alkyl group.

(iii) when Y² = sulphur or oxygen and Y and Y¹ are sulphur by reaction of a compound of the formula (VI)

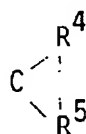


with a compound L¹R³ wherein R to R³, are as hereinbefore defined, Y² is sulphur or oxygen and L¹ is a leaving group eg.halo,

and optionally thereafter converting one compound of the formula (I) to another compound of the formula (I).

2) A process according to claim 1 for preparing a compound wherein R is a phenyl group substituted by 1 to 5 fluorine atoms and optionally substituted at the para position by methyl or chloro.

3) A process according to claim 1 for preparing a compound wherein R is a group



as hereinbefore defined.

4) A process according to any one of claims 1 to 3 for preparing a compound wherein R¹ is hydrogen, cyano, methyl or ethyl each optionally substituted by cyano, methoxy, methylthio, chloro, bromo or fluoro.

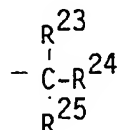
5) A process according to any one of claims 1 to 4 for preparing a compound wherein R² is hydrogen, cyano, methyl or trifluoromethyl.

6) A process according to any one of claims 1 to 5 for preparing a compound wherein R³ is a phenyl group substituted at the 3-, 4- or 5-positions by one to three substituents each selected from halo, C₁₋₄ haloalkyl, cyano, or a group (C≡C)_pR²⁰ wherein p is 1 or 2 and R²⁰ is hydrogen, bromo, chloro or iodo; or R²⁰ is an aliphatic group containing up to five carbon atoms optionally substituted by C₁₋₄ alkoxy, C₁₋₆ alkoxyalkoxy, C₁₋₈ acyloxy, halo or hydroxy; or R²⁰ is SiR¹⁶ R¹⁷ R¹⁸ wherein R¹⁶ and R¹⁷ and R¹⁸ are as hereinbefore defined and the phenyl group is additionally optionally substituted at the 2-and/or 6-positions by fluoro or chloro.

7) A process according to any one of claims 1 to 6 for preparing a compound wherein R³ is phenyl substituted at the 3-, 4- or 5-positions by one to three substituents each selected from halo, cyano, C₁₋₄ haloalkyl or a group C≡C-R²¹ where R²¹ is hydrogen, methyl, or ethyl each optionally substituted by hydroxy, methoxy, ethoxy, acetoxy; or R²¹ is ethynyl, or a silyl group substituted by three C₁₋₄ alkyl groups, R³ is additionally optionally substituted at the 2-and/or 6- positions by fluoro or chloro. Preferably R³ is phenyl para substituted by a group -C≡C-R²² wherein R²² is hydrogen.

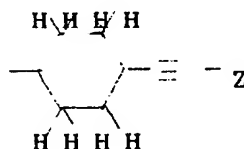
8) A process according to any one of claims 1 to 5 for preparing a compound wherein R^3 is a group $-B-(C\equiv C)Z$, wherein B is a C_{3-5} aliphatic chain optionally containing a double bond and/or an oxygen atom and/or a group $S(O)_q$ wherein q is 0, 1 or 2, and optionally substituted by halo, C_{1-4} alkyl, C_{1-4} haloalkyl, C_{2-4} carbalkoxy or cyano and Z is hydrogen, C_{1-5} alkyl, C_{1-3} alkoxymethyl or a group $SiR^{16}R^{17}R^{18}$ wherein R^{16} , R^{17} and R^{18} are as hereinbefore defined.

9) A process according to any one of claim 1 to 5 for preparing a compound wherein R^3 is a group $-DZ^1$, wherein D is a group $-CH_2O-$ or $CH_2S(O)_q$ wherein q is 0, 1 or 2 or a C_{2-3} aliphatic group each of which may be optionally substituted by one to three halo atoms and Z^1 is silyl substituted by three C_{1-4} alkyl groups or Z^1 is a group



wherein R^{23} , R^{24} and R^{25} are the same or different and are each independently selected from halo, cyano, C_{2-5} carbalkoxy, or a C_{1-4} aliphatic group optionally substituted by halo, cyano, C_{2-5} carbalkoxy, C_{1-4} alkoxy or a group $S(O)_q$ R^{26} wherein q is 0, 1 or 2 and R^{26} is C_{1-4} alkyl, or R^{23} , R^{24} and R^{25} are selected from C_{1-4} alkoxy or a group $S(O)_zR^{27}$ wherein z is 0, 1 or 2 and R^{27} is C_{1-4} alkyl optionally substituted by fluoro or R^{23} and R^{24} are linked to form a C_{3-6} cycloalkyl ring, or one of R^{23} , R^{24} and R^{25} may be hydrogen.

10) A process according to any one of claims 1 to 5 for preparing a compound wherein R^3 is a group



wherein Z is as hereinbefore defined:

11) An insecticidal or acaricidal composition comprising a compound of formula (I) as defined in any one of claims 1-10 in admixture with a carrier or diluent.

12) A synergised pesticidal composition comprising a compound of formula (I), as defined in any one of claims 1-10, a synergist for the formula (I) compound and a carrier or diluent.

13) A mixture of a compound of formula (I) as defined in any one of claims 1-10 and another pesticidal compound.

14) A method for the control of pests comprising application to the pest or to an environment susceptible to pest infestation of a pesticidally effective amount of a compound according to any one of claims 1-10 or a composition or mixture according to any one of claims 11-13.

15) A compound as defined in any one of claims 1-10 or composition according to any one of claims 12-14 for use in a method of surgery or therapy practised on the human or animal body or in a method of diagnosis practised on the human or animal body.



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which under Rule 45 of the European Patent Convention
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Application number

EP 90300721.9

| DOCUMENTS CONSIDERED TO BE RELEVANT | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------------|
| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim |
| A | <u>EP - A2 - 0 243 184</u> (THE WELLCOME FOUNDATION LIMITED) * Claims 1,13,16-19 * -- | 1,11-15 |
| A | <u>EP - A2 - 0 279 698</u> (THE WELLCOME FOUNDATION LIMITED) * Claims 1,10-13 * -- | 1,11-15 |
| A | <u>US - A - 4 772 624</u> (PALMER et al.) * Abstract * ---- | 1,11-15 |
| | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| | | C 07 D 493/00 C 07 D 497/00 |
| INCOMPLETE SEARCH | | |
| <p>The Search Division considers that the present European patent application does not comply with the provisions of the European Patent Convention to such an extent that it is not possible to carry out a meaningful search into the state of the art on the basis of some of the claims.</p> <p>Claims searched completely: 1-14,16 Claims searched incompletely: 15 Claims not searched: - Reason for the limitation of the search: (Method for the treatment of the human or animal body by therapy; Art. 4(52) EPC)</p> | | |
| Place of search VIENNA | Date of completion of the search 22-03-1990 | Examiner BRUS |
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